MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XL. *February* 13, 1880. No. 4.

Lord LINDSAY, M.P., F.R.S., President, in the chair.

Walter H. Bartlett, Esq., 100 Abbey Road, Kilburn; and Captain John Steele, Marine Board, Tower Hill,

were balloted for and duly elected Fellows of the Society.

REPORT OF THE COUNCIL TO THE SIXTIETH ANNUAL GENERAL MEETING OF THE SOCIETY.

Progress and present state of the Society:—

	Compounders	Annual Subscribers	Non-resident	Mathematical Society	Patroness	Total Fellows	Associates	Grand Total
December 31, 1878	218	362	4	6	1	591	40	631
Since elected ...	+ 7	+24	...	...	...	...	+4	...
Deceased	−13	−10	...	−1	...	...	−1	...
Removals	+ 3	− 3	...	...	...	...	...	...
Resigned	− 1	− 5	...	...	...	...	...	...
December 31, 1879	214	368	4	5	1	592	43	635

Mr. Barrow's Account as Treasurer of the Royal

RECEIPTS.

	£	s.	d.	£	s.	d.
Balance at Bankers' Dec. 31, 1878	605	0	3			
„ in hand of Secretary of Library Committee:						
On account of Turnor Fund	1	1	11			
On account of Library Expenses ...	16	12	8			
„ in hand on Petty Cash account	7	14	1			
				630	8	11
Dividend on £6,400 Consols...	94	0	0			
„ £5,700 New 3 per cent. Stock ...	83	14	5			
„ £6,808. 3*s.* 3*d.* Consols	99	19	11			
„ £5,700 New 3 per cent. Stock ...	83	14	5			
				361	8	9
Received on account of Subscriptions:—						
Arrears	135	9	0			
246 Contributions for 1879	516	12	0			
2 „ for 1880	4	4	0			
31 Admission Fees	65	2	0			
24 First Contributions	36	15	0			
				758	2	0
10 Composition Fees				210	0	0
Sales of Publications:—						
At Society's Rooms, 1879	43	19	7			
At Williams & Norgate's, 1878	36	17	9			
				80	17	4
Received from Mr. Edward Lee, being the amount of the purchase of the Advowsons of Hartwell and Stone, pursuant to the Resolution passed at the last Annual General Meeting				700	0	0
Due to Assistant Secretary on Petty Cash Account, Dec. 31, 1879				1	4	5
				£2,742	1	5

Astronomical Society, from Dec. 31, 1878, *to Dec.* 31, 1879.

EXPENDITURE.

	£	s.	d.	£.	s.	d.
Salaries:—						
Editor of *Monthly Notices*	60	0	0			
Assistant Secretary, one half-year, at £150 ...	75	0	0			
,, ,, one half-year, at £225 (as per resolution of Council, Nov. 14, 1879) ...	112	10	0			
				247	10	0
Income Tax and House Duty				9	3	9
Fire Insurance				7	16	6
Printing: Spottiswoode & Co.				561	5	3
Lithography and Engraving:—						
Malby & Sons	64	4	3			
M. & N. Hanhart	12	14	0			
W. H. Wesley	31	6	0			
				108	4	3
Turnor Fund: Books purchased during year ...				32	15	3
Library expenses: Binding				94	5	5
Purchase of scarce volumes of the *Memoirs* ...				2	8	0
House expenses	31	4	6			
Wages	25	16	0			
Stamps and postage	54	9	7			
Carriage of books and parcels	4	12	8			
Stationery and office expenses	4	13	2			
Expenses of meetings	20	0	0			
Coals and gas	44	7	8			
Care of apparatus for extinguishing fire	3	16	8			
Fittings in library	16	19	6			
Sundry fittings and repairs	11	3	10			
Repairs to instrument	11	14	6			
Sundries	5	11	9			
Bankers' commission on cheques	0	1	0			
				234	10	10
Five Gold Medals				52	10	0
Mrs. Jackson-Gwilt's Annuity				8	19	0
Messrs. Merriman & Co.'s charges as to the Advowsons of Stone and Hartwell				50	7	3
Investments:—						
Purchase of £408. 3*s.* 3*d.* Consols, at 98, including commission	400	11	3			
Purchase of £691. 16*s.* 9*d.* Consols, at 97½, including commission	673	13	9			
				1,074	5	0
Balance at Bankers' Dec. 31, 1879	217	7	0			
,, in hand of Secretary of Library Committee:						
On account of Turnor Fund	18	6	8			
On account of Library expenses ...	22	7	3			
				258	0	11
				£2,742	1	5

Examined and found correct, JAMES CAMPBELL.
SIDNEY WATERS.
ROBT. J. LECKY.

Assets and present Property of the Society, January 1, 1880:—

	£	s.	d.	£	s.	d.
Balance at Bankers' Dec. 31, 1879	217	7	0			
, in hand of Secretary of Library Committee	40	13	11			
	258	0	11			
' due to Assistant Secretary on Petty Cash Account...	1	4	5			
				256	16	6
Due on account of Subscriptions:—						
4 Contributions of 6 years' standing ...	50	8	0			
4 „ 5 „ ...	42	0	0			
7 „ 4 „ ...	58	16	0			
4 „ 3 „ ...	25	4	0			
31 „ 2 „ ...	130	4	0			
51 „ 1 „ ...	107	2	0			
Various amounts	19	19	0			
Two admission fees and first contributions	6	6	0			
	439	19	0			
Less two contributions paid in advance ...	4	4	0			
				435	15	0
Due for publications	4	7	0			
„ from Williams & Norgate for sales during 1879	36	19	0			
				41	6	0

£7,500 Consols, including the Lee Fund (£300), the Turnor Fund (£450), and the Horrox Memorial Fund (£100).

£5,700 New 3 per cent. Stock, including Mrs. Jackson-Gwilt's gift (£300).

Astronomical and other MSS., books, prints, instruments, &c.

Five gold medals.

Unsold publications of the Society &c.

Report of the Auditors.

We, the duly appointed Auditors, beg to lay before this General Meeting of the Royal Astronomical Society the following Report:—

We have examined the Treasurer's account, and an account of the assets and property of the Society, and have found and certified the same to be correct.

The receipts and expenditure for the past year are as stated in the Treasurer's account. The cash in hand on December 31, 1879, including the balance at the Bankers', amounts to £258. 0*s.* 11*d.* The funded property of the Society is in a

satisfactory state, and the books, instruments, and other effects have been examined as far as possible and found in a satisfactory condition.

We have laid on the table a list of the names of those Fellows who are now in arrear for sums due at the last Annual General Meeting, with the amount due against each Fellow's name.

ROBT. J. LECKY.
JAMES CAMPBELL.
SIDNEY WATERS.

Stock in hand of volumes of the *Monthly Notices*:—

Vol.	At Society's Rooms.	At Williams & Norgate's.	Vol.	At Society's Rooms.	At Williams & Norgate's.
I.	79	1	XXII.	36	...
II.	79	1	XXIII.	22	...
III.	...	...	XXIV.	24	...
IV.	...	...	XXV.	7	...
V.	...	...	XXVI.	11	...
VI.	46	...	XXVII.	2	...
VII.	2	...	XXVIII.	78	1
VIII.	142	2	XXIX.	57	2
IX.	24	3	XXX.	72	4
X.	177	2	XXXI.	104	2
XI.	186	2	XXXII.	127	5
XII.	11	2	XXXIII.	118	2
XIII.	163	3	XXXIV.	92	3
XIV.	109	3	XXXV.	73	2
XV.	129	2	XXXVI.	41	2
XVI.	110	3	XXXVII.	55	1
XVII.	137	1	XXXVIII.	119	1
XVIII.	167	1	XXXIX.	125	12
XIX.	64	...	Index to *Monthly Notices*	601	...
XX.	37	...			
XXI.	20	...			

In addition to the above volumes of the *Monthly Notices*, the Society has a considerable stock of separate numbers of nearly all the volumes. With the exception, however, of Vols. XXXVI. to XXXIX., no complete volumes can be formed from the separate numbers in stock.

Stock in hand of volumes of the *Memoirs* :—

Vol.	At Society's Rooms.	At Williams & Norgate's.	Vol.	At Society's Rooms.	At Williams & Norgate's.
I. Part 1	9	...	XXIII.	159	1
I. Part 2	46	...	XXIV.	165	2
II. Part 1	61	...	XXV.	177	2
II. Part 2	25	...	XXVI.	181	2
III. Part 1	70	...	XXVII.	436	1
III. Part 2	92	...	XXVIII.	395	...
IV. Part 1	87	3	XXIX.	421	...
IV. Part 2	98	3	XXX.	172	...
V.	112	4	XXXI.	154	2
VI.	131	4	XXXII.	171	3
VII.	155	3	XXXIII.	178	2
VIII.	133	4	XXXIV.	177	8
IX.	142	3	XXXV.	127	3
X.	152	1	XXXVI. (with M.N.)	206	15
XI.	165	1	XXXVI. (without)	15	...
XII.	169	...	XXXVII. Part 1	373	8
XIII.	177	...	XXXVII. Part 2	316	6
XIV.	378	3	XXXVIII.	308	1
XV.	149	1	XXXIX. Part 1	285	2
XVI.	179	...	XXXIX. Part 2	296	3
XVII.	155	3	XL.	326	1
XVIII.	159	...	XLII.	299	3
XIX.	164	...	XLIII.	343	2
XX.	162	2	XLIV.	529	6
XXI. Part 1	314	...	Index to *Memoirs*	669	4
XXI. 1 & 2 (together)	68	1			
XXII.	163	2			

Instruments belonging to the Society.

The Council are glad to be able to state that the instrument catalogued in former reports as "Abraham Sharp's Quadrant" has been found. From notes in the handwriting of Dr. Priestley, now in the possession of the Society, it appears that the instru-

ment was at one time in his possession, and was described by him as "Abraham Sharp's Universal Quadrat."

Information has also been obtained with regard to the existence of "The Reade Transit Instrument" and *Sheepshanks'* Instrument No. 6 (formerly lent to the Rev. Jonathan Cape), both of which were mentioned in the Report of the Council of 1878 as missing. All the instruments referred to in the old Catalogues of the Society are thus accounted for, with the exception of Instrument No. 68, which is described as "A Thermometer."

No. 1. The *Harrison* clock.
,, 2. The *Owen* portable circles, by Jones.
,, 3. The *Beaufoy* circle.
,, 4. The *Beaufoy* transit instrument.
,, 5. The *Herschel* 7-foot telescope.
,, 6. The *Greig* universal instrument, by Reichenbach and Ertel. The transit telescope, by Ultzschneider and Fraunhofer, of Munich.
,, 7. The *Smeaton* equatoreal.
,, 8. The *Cavendish* apparatus.
,, 9. The 7-foot Gregorian telescope (late Mr. Shearman's).
,, 10. The variation transit instrument (late Mr. Shearman's).
,, 11. The universal quadrat, by Abraham Sharp.
,, 12. The *Fuller* theodolite.
,, 13. The standard scale, by Troughton and Simms.
,, 14. The *Beaufoy* clock, No. 1.
,, 15. The *Beaufoy* clock, No. 2.
,, 16. The *Wollaston* telescope.
,, 17. The *Lee* circle.
,, 18. The *Sharpe* reflecting circle.
,, 19. The *Brisbane* circle.
,, 20. The *Baker* universal equatoreal.
,, 21. The *Reade* transit.
,, 22. The *Matthew* equatoreal, by Cooke.
,, 23. The *Matthew* transit instrument.
,, 24. The *South* transit instrument.
,, 25. A quadrant, by Bird (formerly belonging to Captain Cook).
,, 26. A globe showing the precession of the equinoxes.

The *Sheepshanks* collection:—

,, 27. (1) 30-inch transit instrument, by Simms, with level and two iron stands.
,, 28. (2) 6-inch transit theodolite, with circles divided on silver; reading microscopes, both for altitude and azimuth; cross and siding levels; magnetic needle; plumbline; portable clamping foot and tripod stand.

No. 29. (3) $4\frac{6}{10}$-inch achromatic telescope, about 5 feet 6 inches focal length; finder; rack motion; double-image micrometer; two other micrometers; object-glass micrometer; one terrestrial and ten astronomical eyepieces, applied by means of two adapters, with equatoreal stand, clock movement.

„ 30. (4) $3\frac{1}{4}$-inch achromatic telescope, with equatoreal stand; double-image micrometer; one terrestrial and three astronomical eyepieces.

„ 31. (5) $2\frac{3}{4}$-inch achromatic telescope, with stand; one terrestrial and three astronomical eyepieces.

„ 33. (7) 2-foot navy telescope.

„ 34. (8) A transit instrument of 45 inches focal length; with iron stand, and also Ys for fixing to stone piers; two axis levels.

„ 35. (9) Repeating theodolite, by Ertel, with folding tripod stand.

„ 36. (10) 8-inch pillar sextant, by Troughton, divided on platinum, with counterpoise stand and artificial horizon.

„ 37. (11) Portable zenith telescope and stand, $2\frac{3}{4}$-inch aperture and 26 inches focal length; 10-inch horizontal circle and 8-inch vertical circle, read to 10″ by two verniers to each circle.

„ 38. (12) 18-inch Borda repeating circle, by Troughton, $2\frac{1}{8}$-inch aperture and 24 inches focal length; the circles divided on silver, the horizontal circle being read by four verniers, and the vertical circle by three verniers, each to 10″.

„ 39. (13) 8-inch vertical repeating circle, with diagonal telescope, by Troughton and Simms; circle divided on silver, reading to 10″; a 5-inch circle at eye-end reading to single minutes; horizontal circle 9 inches diameter in brass, reading to single minutes.

„ 40. (14) A set of surveying instruments, consisting of a 12-inch theodolite for horizontal angles only, reading to 10″; two sets of adjusting plates; tripod stand with enclosed telescope; heavy stand for theodolite; Y piece of level; two large and three small ground-glass bubbles divided; level collimator, object-glass $1\frac{5}{8}$-inch diameter and 16 inches focal length; micrometer eyepiece, comb, and wires; mercury bottle and trough.

„ 41. (15) Level collimator with object-glass $1\frac{7}{8}$-inch diameter and 16 inches focal length; stand, rider-level, and fittings.

„ 42. (16) 10-inch reflecting circle, by Troughton, reading by three verniers to 20″; counterpoise stand; artificial horizon with mercury; two tripod stands.

„ 43. (17) Hassler's reflecting circle, by Troughton, with counterpoise stand.

No. 44. (18) 6-inch reflecting and repeating circle, by Troughton and Simms, contained in three boxes, two of which form stands. The circle is divided on silver, and is read to single minutes; two inside arcs divided to single degrees, 150 degrees on each side; artificial horizon and mercury.

„ 45. (19) 5-inch reflecting and repeating circle, by Lenoir, of Paris.

„ 46. (20) Reflecting circle, by Jecker, of Paris, 11 inches in diameter, with one vernier reading to 15″.

„ 47. (21) Box sextant; reflecting plane and level.

„ 48. (22) Prismatic compass, by Troughton and Simms.

„ 49. (23) Mountain barometer.

„ 50. (24) Prismatic compass, by Thomas Jones, mounted with a cylindrical lens.

„ 51. (25) Ordinary $4\frac{1}{2}$-inch compass with needle.

„ 52. (26) Dipping needle, by Robinson.

„ 53. (27) Compass needle, mounted for variation.

„ 54. (28) Magnetic intensity needle, by Meyerstein, of Göttingen; a strongly fitted brass box with heavy magnet; filar suspension.

„ 55. (29) Box of magnetic apparatus.

„ 56. (30) Hassler's reflecting circle, by Troughton; a $10\frac{1}{2}$-inch reflecting and repeating circle, with stand and counterpoise, divided on platinum with two movable and two fixed indices; four verniers reading to 10″.

„ 57. (31) Box sextant and glass plane artificial horizon, by Troughton and Simms.

„ 58. (32) Plane $2\frac{3}{8}$-inch speculum, artificial horizon, and stand.

„ 59. (33) $2\frac{1}{2}$-inch circular level horizon, by Dollond.

„ 60. (34) Artificial horizon, roof, and trough; the trough $8\frac{1}{4}$ by $4\frac{1}{4}$ inches. Tripod stand.

„ 61. (35) Set of drawing instruments, consisting of 6-inch circular protractor and common protractor, T-square: one beam compass.

„ 62. (36) A pentagraph.

„ 63. (37) A noddy.

„ 64. (38) A small Galilean telescope with object-glass of rock crystal.

„ 65. (39) Five levels.

„ 66. (40) 18-inch celestial globe.

„ 67. (41) Varley stand for telescope.

„ 69. (43) Telescope, with the object-glass of rock crystal.

„ 70. Portable equatoreal stand.

„ 71. Portable altazimuth tripod.

„ 72. Four polarimeters.

„ 74. Registering spectroscope, with one large prism.

„ 76. Two five-prism direct-vision spectroscopes.

„ 78. $9\frac{1}{4}$-inch silvered-glass reflector and stand, by Browning.

No. 79. Spectroscope.
„ 80. A small box, containing three square-headed Nicol's prisms; two Babinet's compensators; two double-image prisms; three Savarts; one positive eyepiece, with Nicol's prism; one dark wedge.
„ 81. A back-staff, or Davis' quadrant.
„ 82. A nocturnal or star dial.
„ 83. An early non-achromatic telescope, of about 3 feet focal length, in oak tube, by Samuel Scatliffe, London.
„ 84. A Hollis observing chair.
„ 85. A double image micrometer, by Troughton and Simms.
„ 86. A $4\frac{1}{2}$-inch Gregorian reflecting telescope, by Short, with altazimuth stand and 6-inch altitude and azimuth circles and two eyepieces.
„ 87. A $3\frac{1}{4}$-inch Gregorian reflecting telescope with wooden tripod stand.
„ 88. A pendulum with 5-foot brass suspension rod, working on knife edges, by Thomas Jones.
„ 89. A Rhabdological Abacus. A contrivance invented by Mr. H. Goodwyn, consisting of a box filled with compartments, in which are square rods covered with numbers, which can be arranged so as to facilitate the labour of multiplying high numbers.
„ 90. An Arabic celestial globe of bronze, not quite 6 inches in diameter.
„ 91. An astronomical time watchcase, by Professor Chevallier.
„ 92. A 2-foot protractor, with two movable arms, and vernier.
„ 93. A beam compass, in box.
„ 94. A 2-foot navigation scale.
„ 95. Stand for testing measures of length.
„ 96. Artificial planet and star, for testing the measurement of a fixed distance at different position angles.
„ 97. A 12-cell Leclanché battery.

The following instruments are lent, during the pleasure of the Council, to the undermentioned persons:—

No. 4. The *Beaufoy* transit instrument, to the Observatory, Kingston, Canada.
„ 12. The *Fuller* theodolite, to the Director of the Sydney Observatory.
„ 22. The *Matthew* equatoreal, to Mr. Brett.
„ 23. The *Matthew* transit, to Captain Noble.
„ 74. Registering spectroscope, with prism, to Mr. Lecky.
„ 76. One 5-prism spectroscope, to Mr. Plummer.
„ 78. The $9\frac{1}{4}$-inch reflector, to Mr. Neison.
„ 85. Double-image micrometer, to Mr. Common.

From the *Sheepshanks* collection:—

No. 30. (4) $3\frac{1}{4}$-inch equatoreal and stand, to Mr. Sadler.
„ 31. (5) $2\frac{3}{4}$-inch telescope and stand, to Mr. Birt.
„ 34. (8) Transit instrument, to the Rev. Professor Pritchard.
„ 35. (9) Repeating theodolite, to the Sydney Observatory.
„ 39. (13) 8-inch repeating circle, to Mr. Plummer.
„ 43. (17) Hassler's reflecting circle, to Mr. Gill.
„ 69. (43) Telescope, with rock-crystal object-glass, to Dr. Huggins.

The Gold Medal.

No Medal has been awarded by the Council this year.

The Library.

During the year the binding of the Society's books has been proceeded with. Eight hundred and sixty-two volumes have been bound in a substantial manner, at a cost of £94. 5*s*. Altogether since the removal of the Society to Burlington House nearly three thousand volumes have been bound, at a cost of about £450. The Library now contains about eight thousand volumes, and of these nearly one thousand more require binding.

A catalogue, in which the titles of the books are written upon cards, has been commenced, and is nearly half completed. In the first instance the cards will be arranged in alphabetical order, under author's names and catchwords; and when this catalogue is printed the cards will be rearranged so as to form a subject index, which will be kept in the Library for reference.

Publications of the Society.

Vol. XLI. of the *Memoirs*, containing collated accounts of Observations made during total Solar Eclipses, is now ready for distribution amongst the Fellows.

Vol. XLIV. of the *Memoirs* has been published during the past year. It contains the following Papers:—

Mr. E. Neison. "On a General Method of Treating the Lunar Theory."

Mr. N. E. Green. "Observations of *Mars* at Madeira, August and September 1877."

Mr. Maxwell Hall. "Opposition of *Mars* 1877."

Mr. S. W. Burnham. "Double Star Observations made in 1877–78 at Chicago with the $18\frac{1}{2}$-inch Refractor of the Dearborn Observatory."

Obituary.

The Council regret that they have to record the loss by death of the following Fellows and Associates during the past year:—

Fellows:—J. R. Christie.
W. K. Clifford.
J. T. Cooper.
George Creaser.
H. M. E. Crofton.
Richard Farley.
Isaac Fletcher.
H. J. Gibson.
J. G. C. C. Godsman.
Sandford Gorton.
The Very Rev. H. P. Hamilton.*
Sir Rowland Hill.
C. H. Johns.
W. E. Jones.
Charles Judd.
Rev. H. C. Key.
Sir Thomas Maclear.
Henry Mann.
Rev. J. N. Peill.
J. E. Richard.
Rev. A. Robertson.
Benjamin Templar.
John Waterhouse.
S. C. Whitbread.
Richard Wilding.

Associate:—Prof. J. Lamont.

James Robert Christie, F.R.S., second son of the late Professor S. H. Christie, for some time Secretary of the Royal Society, was born at Woolwich on February 9, 1814, and early acquired from his father a taste for mathematics. In 1837 he was appointed a mathematical master at the Royal Military Academy, Woolwich, and was, ten years later, promoted to the post of first mathematical master in the same institution, an appointment which he held till 1865, when he retired on a pension. Mr. Christie was the author of an "Introduction to Practical Astronomy," in which is given a clear exposition of the principles used in the reduction of observations, and of a "Collection of Elementary Test Questions in Mathematics." He also wrote papers "On the Extension of Budan's Criterion for the

* An obituary notice of Mr. Hamilton will appear in the next *Annual Report.*

Imaginary Roots of an Equation" (*Phil. Mag.*, 1842), and "On the Use of the Barometric Thermometer for the Determination of Relative Heights" (*Phil. Trans.*, 1846). His chief work was in connection with the Royal Military Academy, where he ably seconded the efforts of his father to raise the character of the mathematical studies at that institution. He died at Norwood on February 28, 1879. He was elected a Fellow of the Society on January 13, 1854.

William Kingdon Clifford was born at Exeter on May 4, 1845. His father was a well-known and active citizen, and filled the office of Justice of the Peace; his mother he lost early in life. He was educated at Exeter till 1860, when he was sent to King's College, London. In 1863 he came into residence at Trinity College, Cambridge, having previously obtained a minor scholarship. He was elected a scholar of the College, and graduated as second wrangler in 1867, Mr. Charles Niven being the senior wrangler in that year. He was also second Smith's prizeman. In 1868 he was elected Fellow of Trinity and appointed Assistant Tutor. In 1871 he was elected to the Professorship of Applied Mathematics at University College, London, an office which he held till his death. On April 7, 1875, he married Lucy, daughter of Mr. John Lane, and granddaughter of Blandford Lane, of Barbados. In the spring of 1876 grave indications of a pulmonary disease were noted; these gradually increased, and in April 1878 he was compelled to leave England for the Mediterranean, when he visited Gibraltar, Venice, Malta, &c. There being signs of improvement, he returned to London in August 1878. A relapse, however, took place in September, and his strength began visibly to diminish. At the beginning of 1879 he sailed for Madeira, his friends hardly expecting him to survive the voyage. He arrived there, however, safely, and some weeks were thus added to his life, the change of climate enabling him to spend his last days in ease and comparative enjoyment. He died on March 3, 1879.

His first papers, published while he was an undergraduate, are "Analogues of Pascal's Theorem" (*Quarterly Journal of Mathematics*, vol. vi., 1863) and "On Jacobians and Polar Opposites" (*Messenger of Mathematics*, vol. ii., 1864); one of his last completed papers seems to have been that "On the Classification of Loci," which appears in the *Philosophical Transactions*, 1878. Most of his contributions to mathematics were communicated to the London Mathematical Society. He published in 1877 the first portion of a book entitled *The Elements of Dynamic*, but his health prevented him from completing it. Many of the new terms employed in this work are already coming into general use. He left in manuscript a considerable portion of a book *On the Common Sense of the Exact Sciences*, which is now being edited by Mr. R. C. Rowe, Fellow of Trinity College, Cambridge, and will shortly be printed.

Among the best-known of Clifford's general writings may be mentioned his lectures "On Some of the Conditions of Mental Development," delivered before the Royal Institution on March 6, 1868, and "On the Aims and Instruments of Scientific Thought," delivered before the British Association at Brighton on August 19, 1872. Several also of his addresses before the Sunday Lecture Society were published and attracted considerable attention. His *Lectures and Essays* have since his death been edited by Leslie Stephen and Frederick Pollock, and published in two vols. 8vo., with an introduction, partly biographical, by F. Pollock; a republication of his mathematical writings, edited by Mr. R. Tucker, is in the press.

Clifford was one of the few mathematicians who can with justice be said to have shown real mathematical genius: everything that he did was distinguished by an originality which rendered his work unique. He died at the early age of 34, and a great portion even of this short life was devoted to philosophy, metaphysics, and subjects of more general interest; so that it is difficult to realise the position he might have attained to in mathematical science had he confined his attention more exclusively to it, and had his life been longer. As it is, the scientific position he has gained is a permanent one, and it will always remain a matter of surprise how it was possible to write the brilliant papers he has left us among the distractions of so many other occupations.

He was elected a Fellow of this Society on December 12, 1873, and of the Royal Society on June 4, 1874. He was a member of the Sicilian Expedition to observe the Eclipse of December 22, 1870, and the account of his observations is published in vol. xli., pp. 310–311, of the *Memoirs* of the Society. A few remarks of his on the subject are also contained in vol. ii. of the *Proceedings of the Cambridge Philosophical Society* (February 27, 1871).

Joseph Thomas Cooper was born in London May 25, 1819, and died November 17, 1879. At an early age he evinced considerable talent for music, and was placed under Mr. William Holmes, of the Royal Academy of Music; he finished his education with M. Moscheles, then resident in England, and who subsequently became Principal of the Conservatoire at Leipzig. In 1837 Mr. Cooper was appointed organist of St. Michael's, Queenhithe; in 1844, of St. Paul's, Ball's Pond, London; in 1866, of Christ Church, Newgate Street; and, in 1876, of Christ's Hospital. The two latter appointments he held until his death. He was a member of the old Mathematical Society, and became a Fellow of the Royal Astronomical Society in 1845, when the former society was merged into the latter. His time, however, was so occupied with professional duties, that he was

unable to devote so much attention to scientific pursuits as he desired. He was also a member of the Philharmonic and other musical societies. For several years he was musical editor of the periodical *Evening Hours*.

George Creaser, the fourth son of Francis and Elizabeth Creaser, was born at Scampstone Lodge, near Walton, on February 25, 1802. The first six or seven years of his life he spent at Scampstone; the family then removed to Milnsbridge, near Huddersfield, his father becoming the steward and surveyor of Sir J. Radcliffe. When a boy his health completely gave way. Up to the age of eighteen he manifested no signs of what he was likely to be; but one of his elder brothers, William Creaser, having begun to devote his leisure hours to making telescopes, George joined him in this work, and began the study of Optics and Astronomy, which he steadily pursued. He married, about 1830, Miss Turner, of Selby, who died about eight years afterwards. He then gave up his whole time to the manufacture of telescopes, microscopes, &c., and continued to do so till his death. Few men have done so much work of this kind, especially with such simple tools. He died at Meltham, near Huddersfield, on April 21, 1879. He was elected a Fellow of the Society on February 13, 1874.

Henry Morgan Earbery Crofton, eldest son of the Rev. Henry William Crofton, of Inchinappa House, Ashford, County Wicklow, Ireland, succeeded to the considerable family estates on the death of his father.

He was educated at Trinity College, Dublin, and at an early age showed a decided taste for practical astronomy; and shortly after the completion of his University career provided himself with an 8-inch Equatoreal by Cooke, of York, and other astronomical instruments.

He resided until his early and untimely death upon his Inchinappa estate, and took considerable interest in its cultivation and improvement.

For many years he owned a yacht, in which, during the summer, he annually attended the regattas in the South and West of England and on the Irish coasts.

He married the daughter of Major Townsend, of Wicklow, County Inspector. His wife, by whom he left a young and numerous family, survived him only by a very brief period.

He was elected a Fellow of the Society on January 10, 1863.

Solomon Moses Drach was born in Bury Street, St. Mary Axe, London, in 1835. He went to a school kept by Mr. Cutler, in Devonshire Street, and afterwards to one kept by Mr. Tait, where he remained two years. His own name was Solomon

Moses, and he took the name of Drach from his aunt's husband, Mr. Liepman Woolf Drach, who (after his aunt's death) left him his fortune. He married, on August 4, 1841, his cousin Rebecca, the daughter of another aunt who had also been adopted by Mr. L. W. Drach. His uncle died on April 18, 1840, and he continued his business of a commission agent till the death of his aunt, which occurred on June 9, 1847, when he devoted himself to study, being chiefly interested in mathematics, astronomy, and biblical and antiquarian subjects.

Mr. Drach's first published paper appeared in the *Philosophical Magazine* for 1839, and was entitled "On the use of Barometrical Formulæ for determining the Heights of Mountains." He published also, in the *Philosophical Magazine* for 1849, several papers on mathematical questions relating to the description of epicyclical curves. These also had reference to, and contained some account of, the epicycloidal curves which Mr. Perigal had traced geometrically in 1835, and by continuous circular motions in 1840. Mr. Drach published numerous short papers in the *Monthly Notices* of the Society. He was also a frequent contributor to the library of the Society, having presented at different times many volumes, chiefly old astronomical and mathematical works; and after the removal of the Society to Burlington House he passed much of his time in the library, working at his favourite subjects. Some years ago he presented to the Royal Society two large volumes containing resolutions of numbers into sums of squares and cubes; and he devoted much of his time to work of a similar kind. He died, at 23 Upper Barnsbury Street, Islington, on February 8, 1879. He was elected a Fellow of the Society on May 14, 1841.

Mr. Drach was a member of the old Mathematical Society, and became a life Fellow of this Society when the former was merged into it in 1845.

Richard Farley was for a long period connected with the *Nautical Almanac* Office, first as an ordinary computer and afterwards as First Assistant. He was one of a number of young computers collected together in 1831 by Lieutenant Stratford, Superintendent of the *Nautical Almanac*, for the calculation of the first volume of the enlarged series of that work, according to the recommendations drawn up by a Committee of the Royal Astronomical Society in November of the preceding year. Though little more than twenty years of age, Mr. Farley had at this time already attained a good reputation as an accurate computer, and he was at once intrusted by Lieutenant Stratford with the calculations of the places of the Sun and the lunar distances for the *Almanac* for 1834, as well as with the general examination of most of the computations. After the resignation in 1837 of Mr. Woolhouse, First Assistant, Mr. Farley was chosen to succeed him in that important and responsible office, which he filled more

than thirty years with the greatest devotion to the work, under the superintendence of Lieutenant Stratford and Mr. Hind, even beyond the ordinary business hours of the office, till his superannuation about ten years ago. He was succeeded by Mr. W. Godward, the present Chief Assistant.

Mr. Farley's skill in calculation was well known to a large number of astronomers, who have often availed themselves of his services to assist in carrying out the reduction of large masses of observations, especially in the formation of general catalogues of stars. His first employment on these miscellaneous calculations, few of which are known to the astronomical world, was his engagement by Mr. Baily to assist in completing what at that time was considered a very important publication, the *Astronomical Society's Catalogue of* 2,881 *Stars*. When Mr. Baily undertook to superintend the compilation of a larger general catalogue of stars, which afterwards assumed the form of the *British Association Catalogue*, he again secured the assistance of Mr. Farley, in whose hands the superintendence of the reductions was placed. In this very laborious work he was assisted by Mr. Russell and Mr. Alger, two of his colleagues in the *Nautical Almanac* Office, but on him rested the entire responsibility for the accuracy of the computations. The magnitude of the reductions was sufficient to absorb the whole of Mr. Farley's unofficial time; and the work was performed to the satisfaction of Mr. Baily, who has acknowledged that it is to the labour, care, and attention of Mr. Farley in particular that the public are indebted for this well-known and popular Catalogue.

The convenient tables of logarithms, in imitation of the tables of Lalande, issued in 1839 under the superintendence of the Society for the Diffusion of Useful Knowledge, but more commonly associated with the name of Professor De Morgan, was carried through the press by Mr. Farley, who, in his most careful manner, examined the proof-sheets with Lalande's work, and afterwards with Vega's edition of Vlacq. Before the tables were stereotyped the differences were all retaken and the work examined throughout by Mr. Farley. It is therefore to him that astronomers and others have been principally indebted for the use of this conveniently arranged pocket volume of tables of logarithms. The reprint of Barlow's useful tables of squares, cubes, square roots, cube roots, and reciprocals, issued in 1840 by the above Society, was also carried through the press by Mr. Farley, by whom all the proofs were carefully read, and the numbers examined by second and third differences. Other works of a similar kind have also had the advantage of his assistance.

Though Mr. Farley's astronomical labours have been chiefly devoted to the assistance of others, he has made original investigations on the orbits of *Pallas* and *Vesta*, taking into account the perturbations by the principal planets. The annual ephemerides for these two minor planets, given in the *Nautical Almanac*, have been calculated from his elements. Mr. Farley was elected a

Fellow of the Society on March 8, 1850, and served four years on the Council, 1860–1864.

Isaac Fletcher, F.R.S., of Tarnbank, Cumberland, was born on February 22, 1827. He was the second son of John Wilson Fletcher, of Tarnbank. His mother, Mary, was a daughter of John Allason, of Beech Hill. He married, on December 13, 1861, Esther, daughter of the late Mr. Joseph King, of Wassall Grove, Stourbridge. He unsuccessfully contested Cockermouth in April 1868, but was elected at the general election in the following November, and retained the seat till his death. His politics were liberal. He was a Justice of the Peace for Cumberland. He died by his own hand, in London, on April 3, 1879.

Mr. Fletcher was elected a Fellow of this Society on May 11, 1849. He at first used a telescope of 4·16 inches aperture, for which he built a small observatory, described in vol. x., p. 137, of the *Monthly Notices*; subsequently he obtained a telescope of $9\frac{1}{2}$ inches aperture, the mounting of which is described in vol. xxv., p. 242. He chiefly devoted himself to micrometrical measurements of double stars, and several communications of his on this subject have appeared in the *Monthly Notices*. He was elected a Fellow of the Royal Society on June 7, 1855.

Sandford Gorton early evinced a taste for mechanical and scientific pursuits, and astronomy soon became the principal occupation of his leisure. Soon after his marriage he went to reside at Stamford Villa, Downs Road, Clapton, where he established an Observatory. His principal telescope, which was of $3\frac{3}{8}$-in. aperture, by Ross, was first mounted on an equatoreal stand by Cooke, and afterwards upon a stand with clock motion by Dallmeyer. To his instruments and Observatory Mr. Gorton was constantly adding ingenious contrivances. He became an ardent and persevering general observer, keeping an accurate record of his work. He was an excellent draughtsman, and his delineations of sun-spots and planetary features are marked by careful execution and strict fidelity. In 1861 he presented a series of 111 Indian-ink drawings of *Jupiter*, made between 1839 and 1861, to the Society (*Monthly Notices*, vol. xxii., p. 60). It was during his residence in the Downs Road that Mr. Gorton determined to establish a purely astronomical periodical. In the address which accompanied the first number of the *Astronomical Register*, he states that it occurred to him that it would be very desirable "to collect together those stray fragments of information which, though not of sufficient importance possibly to occupy the pages of the *Monthly Notices*, may nevertheless, in the shape of passing conversations, or occasional notes, be useful for future reference,"

and that he wished "to introduce a sort of astronomical *Notes and Queries*, a medium of communication for amateurs and others," believing that "many valuable contributions to the science are now scattered in different publications: collected in one periodical they would be of far more benefit to the astronomical inquirer than they are now." Mr. Gorton was also of opinion that an account of the discussions which took place at the meetings of this Society should be published, both for the sake of those who were unable to be present, and also in order that some permanent record of them should be preserved; and the admirable reports of our proceedings contained in the *Astronomical Register* have always formed one of its chief characteristics. The first number appeared in January, 1863, and the whole of the first volume was printed by Mr. Gorton himself, at his own private printing press. The frontispiece of this volume is a plate of *Jupiter*, from a sketch by Mr. Gorton.

On his removal to his residence, Parnham House, Pembury Road, Clapton, he gave up his Observatory, and was often heard to express his regret that he had been compelled to abandon it, after all the labour that he had devoted to its construction. His health at this time began visibly to decline, but he nevertheless continued to edit and manage the *Astronomical Register*, in which he took the greatest interest, until 1872, when he was compelled with much reluctance to relinquish it. Since this time it has been continued by the Rev. J. C. Jackson.

Mr. Gorton had always a great fondness for nautical matters, and during the last five or six years of his life he resided during the summer and early autumn months in his yacht, the "North Star"; there is no doubt that the change of scene and pure and bracing breezes which he thus met with somewhat prolonged his life. His debility continually increased, and was at length succeeded by utter helplessness. He died on February 14, 1879, in his 56th year. He was elected a Fellow of the Society on June 8, 1860.

Sir Rowland Hill, the third son of Thomas Wright Hill, was born at Kidderminster on December 3, 1795, in a house which had belonged to his forefathers for some generations. The war with France had caused the ruin of the business in which his father was engaged, and the family was reduced to great straits. In her desire to secure an education for her children, his mother persuaded her husband to give up trade, for which he was very little fitted, and establish a school near Birmingham. At the age of eleven Rowland began to assist his father in teaching, and a year later he had ceased to be a pupil and had become altogether a teacher. While still quite a youth he and his brother Matthew began to discover the deficiencies in their father's school, and to set about reforming them. Matthew chiefly concerned himself with improving the instruction, while Rowland dealt with the

discipline and organisation. "Organisation," he used to say in after life, "is my forte." He aimed at making the boys govern themselves. A constitution was promulgated, and a code of laws was made, which fills more than a hundred pages of a closely printed volume published in 1827 when they had been in operation for fully ten years. A complete democracy was established, each boy having even the right of being tried by a jury of his schoolfellows whenever a charge was brought against him by one of the masters. In the *Essays of a Birmingham Manufacturer*, Mr. W. L. Sargant gives an account of the school and the system, the chief objection which he makes to it being that the boys were made premature men.* In a volume entitled *Public Education*, written chiefly by his brother Matthew, Rowland's new system was made known to the world. The book at once excited considerable public attention, and an article upon it appeared in the *Edinburgh Review*. Rowland used to boast that at this time he had the largest school in Warwickshire. After living at Birmingham till he was more than thirty, he removed to the neighbourhood of London, where, with the aid of one of his brothers, he established a branch school at Bruce Castle, Tottenham. But by this time his health, which had always been delicate, began to give way, and at length broke down. He had certainly tried it ever since childhood by the severest and the most prolonged labour. His work as a schoolmaster also had become distasteful to him, and he longed for a change. His means were very small, but he did not hesitate to give up his business in the full conviction that, with the powers he knew he had, he was as certain of success in some other path as a man could be. He always preserved, however, the strongest interest in his school, which was carried on by his younger brother Arthur. Rowland, as soon as his health was re-established after a long period of rest, began to cast about for a new employment. He had long been known to many leading men among the advanced Liberal party, not only by his work as a schoolmaster, but also as an eager advocate of political and social reform. He had assisted in founding the Society for the Diffusion of Useful Knowledge. He had published a plan for the gradual extinction of pauperism and for the diminution of crime. Shortly after his retirement from the school an association was formed for the colonisation of South Australia on the plan of Mr. E. G. Wakefield. In this he took an active part, and when the Act was carried through Parliament and a Commission was appointed, he was named secretary. He held this post for four years, and during this time he gave up most of his leisure to the invention of a printing machine. While he was still labouring at this machine, he began to interest himself in postal matters. He hesitated for a long time between his printing press and his postal project, but at length, being obliged to make a choice, he preferred the latter.

* Essay III. *Middle Class Education*, vol. ii., p. 191.

It is not needful to dwell on the state of the Post Office before Rowland Hill reformed it. Its charges were high and arbitrary, and its services were limited and irregular. There were districts larger than the county of Middlesex in which the postman never set foot. For the 11,000 parishes of England and Wales there were only 3,000 post offices. A single letter from London to Edinburgh was charged *1s.* 1½*d.* If it contained the smallest enclosure—a receipt, for instance—it was charged the double, *2s.* 3*d.* Two separate pieces of tissue paper sent in one enclosure would have been charged twice as much as the heaviest letter that was written on a single sheet. The upper classes, through the right of franking which was enjoyed by every member of Parliament, had to some extent their letters carried free of charge; and the traders, by the help of illicit means of conveyance, were often able to evade the heavy tax. The poor man, however, was helpless; he could not afford to use the Post Office, and had no other means of sending a letter. Under this system the postal revenue had remained stationary for twenty years. In 1835 the general revenue of the country showed a large surplus, and Rowland Hill began to speculate how it might be best employed. No tax, on examination, proved so defective as the tax on letters, and he then applied himself to investigate the state of the Post Office by the aid of the Parliamentary Reports. When he first turned his attention to the practicability of reforming the Post Office, he had no idea of uniformity of rate. He found it most difficult to obtain accurate statistics; but at length he discovered that the cost of conveying a letter from London to Edinburgh was only the 36th part of a penny, and that the cost of conveyance was so insignificant that a uniform rate could not only be established, but was "absolutely fairer than any other." He also formed large and bold schemes for the reorganisation of the Post Office. In 1837 he published his plan in a pamphlet entitled "Post Office Reforms." Associations were formed to carry it through, and petitions to Parliament in its favour soon began to pour in. In 1838 a select committee of the House of Commons was appointed to consider the plan: uniformity of postage was carried only by the casting vote of the chairman. A two-penny rate of postage was recommended. The Ministry still seemed indisposed to adopt the plan; but after a deputation of 150 members of Parliament, all supporters of the Government, had waited upon the Premier, Lord Melbourne, they yielded, and penny postage came into effect on January 10, 1840.

In order to carry out the reforms, Rowland Hill was appointed for two years to an office in the Treasury, at a salary of £1,500 a year. He had very little power given to him, and all the officers of the Post Office were against him, so that his position was very trying and painful. On Sir Robert Peel coming into office his services were dispensed with by the Government; but a national testimonial was raised, and at a public dinner he was presented with a cheque for £13,000. He then became a director,

and afterwards chairman, of the London and Brighton Railway Company, and it is stated that on his recommendation as chairman the first excursion train and the first express train were run.

In 1846, when the Liberals returned to power, he was offered an office in the Post Office itself. He was appointed, however, not Secretary to the Post Office, but Secretary to the Postmaster-General, so that the old double government was continued; and it was not till 1854, fourteen years after penny postage had been established, that, by his appointment as sole secretary, he was free to carry out his plans. He was in this greatly aided by his youngest brother, Frederick, who was transferred from the Home Office to the Post Office.

In 1860 he was made a K.C.B., and in the same year the late Lord Stanley of Alderley was appointed Postmaster-General. Differences arose between him and Sir Rowland, chiefly upon the question of promotion by merit, which the latter had succeeded in introducing into the Post Office, with the sanction of his previous chiefs, in place of the system of patronage. Sir Rowland appealed in vain to the Treasury, and accordingly, his health also failing him, he sent in his resignation in 1864. The House of Commons granted to him, on the recommendation of Her Majesty, the sum of £20,000, without a division, and in addition he received his full salary of £2,000 a year for life. In 1865 he was appointed a member of a Royal Commission on Railways. He received the degree of D.C.L. from Oxford, and only a few weeks before his death the freedom of the City of London. He was elected a Fellow of the Royal Society on June 11, 1857.

He was one of eight children, six sons and two daughters, all of whom reached adult age. He married, in 1827, Caroline, eldest daughter of Mr. Joseph Pearson, of Graisley, near Wolverhampton, who survives him, and by whom he had four children, one son and three daughters. He passed away unconsciously, at his residence at Hampstead, at half-past four o'clock in the morning of August 27, 1879, and was buried in Westminster Abbey on September 4. Sir Rowland was one of the oldest Fellows of this Society, having been elected more than 57 years ago, viz. on November 8, 1822. At the time of his death there were but two older Fellows of the Society, and one of these, the Rev. H. P. Hamilton, Dean of Salisbury, has since died.

William Edward Jones, being then resident in Leamington, began his astronomical pursuits about 1860, with a fine 4-inch Refractor equatoreally mounted on a moveable tripod. This he afterwards replaced by a 5-inch instrument by Dallmeyer, which he erected first at Brighton and subsequently at his residence in Gloucestershire. Two years ago he added a 9-inch Browning-With Reflector, but his failing health allowed him to make but little use of this. He was chiefly interested in double stars. He died at Hyères after a short illness, at the age of 57. He was elected a Fellow of the Society on May 12, 1865.

Charles Judd was born at Edmonton on March 23, 1826, and was educated at the Edmonton Grammar School, then called Latymer's School. At the age of 16 he went to the Westminster Training College. Upon resigning an appointment which he had obtained in the Rev. Mr. Bertie's school at Ilford, he became the head master of the "Yellow School," at Cirencester. Here he laboured assiduously for some years, undertaking, in addition to his ordinary work, the delivery of public lectures on Astronomy, Physical Geography, and other branches of science. In 1854 he resigned this appointment, and became an assistant master in Denmark Hill Grammar School. In 1858, after a brief interval, in which he was connected with Stockton Grammar School, he was elected second master of the Foundation School, Whitechapel, and about ten years subsequently became head master. This post he retained until his death, which took place after a short illness at Freiburg, Baden, to which place he had gone to recruit his strength during the autumn vacation. Mr. Judd was a member of the Numismatic Society, an Associate of King's College, a Fellow of the Geological Society, and had been for some years a member of the Council of the College of Preceptors. He was also for several years an active member on the London Committee for the Oxford Local Examinations. He leaves a widow and four children. He was elected a Fellow of the Society on June 14, 1867.

Henry Cooper Key, M.A., was the eldest son of the celebrated surgeon, C. Aston Key, of Guy's Hospital. He was born in 1819, and educated at private schools, and at Christ Church, Oxford, where he took his degree in 1842. He early showed a taste for astronomy, and while quite a boy constructed a telescope. After being four years in orders, he was presented by Guy's Hospital to the living of Stretton Sugwas, in Herefordshire: the parish being very small, he had leisure for scientific pursuits.

In 1859 he began his attempts to grind glass mirrors for Newtonian reflectors, then a most difficult task, the process having been almost lost; but after some years' persevering efforts, in co-operation with Mr. George With, of Hereford, he succeeded in inventing a method by which great accuracy of figure could be obtained.

After making several mirrors of increasing diameters, he attained the object of his ambition, a speculum of 18 inches diameter and 11 feet focus. On achieving this success, he discontinued the mechanical work of mirror-making, and used his splendid instrument in observing. Its great light-collecting power and admirable definition rendered it especially suitable for studying faint objects. He discovered the remarkable depression in the Moon's surface which has been named after him, and contributed observations of comets, nebulæ, &c. to the *Monthly Notices* at intervals. He was much interested in other branches of science, such as ancient chronology, geological periods, the tidal wave in the Medi-

terranean, &c., and was engaged in the last weeks of his life in observing the periodical earth-vibrations noticed by Plantamour and D'Abbadie, which he expected would have thrown light on obscure geological and meteorological questions. From careful observations made with accurate instruments, he believed that, the elements from which a law might be deduced had been obtained.

After a short illness, he died on December 25, 1879, aged 60. He was elected a Fellow of the Society on November 9, 1860. His paper "On a mode of figuring glass specula for the Newtonian telescope" appeared in vol. xx., pp. 199–202, of the *Monthly Notices*, and that "On certain depressions on the Moon's western limb" in vol. xxiv., pp. 20–23.

Sir Thomas Maclear, formerly Her Majesty's Astronomer at the Cape of Good Hope, was the eldest son of James Maclear of Newton Stewart, Tyrone, Ireland. He was born on March 17, 1794, and died at his residence, Grey Villa, Mowbray, Cape of Good Hope, on July 14, 1879. His early childhood gave promise of the talents that distinguished the future man, and his proficiency in Latin when only seven years old caused his father to wish him to enter the Church. An attempted coercion in this matter ended finally in a breach between father and son; the funds required for his education as a medical man were placed in the hands of friends, and he was dismissed to England, at the age of 15, to the care of his maternal uncles, Sir George and Dr. T. Magrath, both eminent medical men.

He studied at Guy's and St. Thomas's Hospitals, and passed his examinations in all branches of his profession with high honours. Brilliant prospects were opened before him in London; but he preferred a quieter life, where he could follow with more advantage his mathematical and astronomical studies, which already were becoming to him a necessity of life. He was accordingly elected house-surgeon of the Bedford Infirmary, where, in the congenial society of Admiral Smyth and others, he combined with the practice of his profession a gradually increasing study of astronomy.

In 1823 he moved to Biggleswade, where he practised his profession; and in 1825 he married Mary, third daughter of Mr. Theed Pearse, for many years clerk of the peace of the county of Bedford. His astronomical pursuits daily absorbed him more and more, and he built a little observatory in his garden, in which he spent every moment he could spare.

In 1833 he was appointed Her Majesty's Astronomer at the Cape of Good Hope. He reached his new sphere of labour on January 5, 1834, and took up his residence at the then desolate-looking Observatory.

Ten days afterwards Sir John Herschel arrived at the Cape, and the next four years were spent in happy mutual intercourse

between the two astronomers, each assisting with heart and soul the labours of the other. From the date of Mr. Maclear's arrival the records of the Observatory bear ample testimony to his devotion and zeal, and show that he applied himself to the execution of his duties as laid down in his official instructions, with the untiring energy which distinguished him.

The Transit Instrument and Mural Circle were kept in constant use, and a large amount of most valuable material was accumulated. Under the clear skies of the Cape it was inevitable that with a man of such a temperament observations would far exceed the computing powers of his staff. The personal establishment of the Observatory at the time was much too limited to enable the astronomer to reduce and publish the great mass of observations which he accumulated. The actual force on duty at the Observatory was as follows: from January 1834 to December 1834, the astronomer and one assistant; December 1834 to October 1835, the astronomer; October 1835 to October 1839, the astronomer and one assistant; October 1839 to October 1845, the astronomer and two assistants.

In 1838 the first part of his great work, *The Verification of Lacaille's Arc of the Meridian*, was commenced. The measurement of this arc and its extension were commenced in 1840, and the field work was finished in 1847.

It is impossible to convey within the limits of this notice any adequate idea of the indomitable energy and perseverance with which this operation was carried out, of the difficulties surmounted, and of the extent and value of the work accomplished with limited means. That all this was fully recognised at the time is sufficiently testified by the fact that for this work he received the Royal Medal of the Royal Society of London and the Lalande Medal of the Institute of France.

Besides the great value of this survey in a geodetic sense, it forms the groundwork of the survey of the colony, and has given to that operation in certain parts of the country a character and completeness which it would otherwise have lacked.

In 1847 a 46-inch Achromatic Telescope by Dollond was mounted equatoreally, and in 1849 an Equatoreal by Merz, of 7 inches aperture and 8½ feet focal length, was added to the instrumental equipment of the Observatory.

These instruments were vigorously employed in the observation of double stars, comets, and nebulæ, and of occultations of stars by the Moon. The results of many of these observations have been published from time to time in the *Memoirs* of this Society, but some of the most valuable series still remain to testify still more strongly to the unwearied activity and skill of Mr. Maclear as a practical astronomer. The original records show that the observations were sustained nearly all night long, and there are frequent notes to the effect that the observations have been brought to a close by the rising Sun.

Simultaneously with these observations the meridian instruments were worked with redoubled energy, and during the years 1849–53 the whole of the stars of the B.A.C. having south declination were observed generally three times in both coordinates. The energy with which this series of observations was carried on is shown by the fact that in the year 1852 between 9,000 and 10,000 observations of right ascension were made with the Transit-Instrument, on some nights over 100 stars having been observed. The reduction of these observations, with a view to their early publication as the "Cape Catalogue for 1850," now occupies the attention of Her Majesty's Astronomer.

In 1855 the new Transit-Circle (a facsimile of the Greenwich Transit-Circle) arrived. It was duly mounted with the assistance only of local masons and labourers, and observations were commenced with it at the end of the same year.

In 1859 Mr. Maclear paid a visit of a few months to England, and keenly enjoyed the seeing of old friends and making the personal acquaintance of many men only known to him by repute or by correspondence.

He returned to the Cape in 1860, and in June of the same year he received the honour of knighthood, a well-merited recognition of his labours in science. After the year 1860 Sir Thomas Maclear's attention was chiefly directed to the reduction of his previous observations. He reduced the valuable series of observations made in the years 1835–40, which have since been revised by Mr. E. J. Stone, Sir Thomas Maclear's successor, now Radcliffe Observer, and formed by him into the Cape Catalogue for 1840, containing 2,892 stars. Sir Thomas also partially reduced the observations made with the new Transit-Circle in the years 1856–60, a work completed by his successor, and published under the title of the "Cape Catalogue for 1860."

All comets visible in the southern hemisphere were diligently observed by him with the Equatoreal, and the places of the comparison stars observed with the Transit-Circle. The results of these observations were always promptly reduced and published in the *Memoirs* or *Monthly Notices* of this Society.

Amongst these may be quoted the following series: 1835–36, Halley's Comet; 1842, Encke's Comet; 1844, Mauvais' second Comet; 1844–45, Wilmot's Comet; Comet of 1843; 1846, Biela's Comet; 1850, Petersen's Comet; 1853–54, Klinkerfues' Comet; 1855, Encke's Comet; 1857, D'Arrest's Comet; 1858–59, Donati's Comet; Comet III, 1860; Comet I, 1861; 1861–62, Encke's Comet; Comet II, 1862; Comet I, 1865; 1865, Encke's Comet.

He determined the parallax of α *Centauri*, confirming Henderson's result of an annual parallax amounting to nearly 1″ of arc. He accumulated a fine series of observations of the most interesting binaries in the southern heavens, which is still unpublished.

He made a long-continued series of observations of the Moon

and of Moon-culminating stars for the purpose of determining the longitude of the Observatory and the parallax of the Moon.

Besides these varied astronomical labours he gave much attention to meteorological, magnetic, and tidal observations. He was successful in exciting an interest throughout the colony in meteorological observation, and was always ready to lend a helping hand to any student of science.

He threw himself with heart and soul into all measures by which he could promote the well-being of the colony. He was a member of the Examining Board; for many years he assisted in the establishment of lighthouses, and was the originator of, and took part in a commission on standards of weights and measures. He felt the keenest interest in sanitary matters, and in cases of emergency has lent his medical assistance.

He was the intimate friend of Livingstone. Their acquaintance commenced in 1850, when Livingstone came to him for assistance as to the best means of ascertaining his position when on his travels. Livingstone's quickness and aptitude for the work won Maclear's heart: the men were kindred spirits, and their firm friendship continued to the end.

The reduction of Livingstone's observations was performed at the Observatory, and formed a serious item in the work undertaken; but the labour was a labour of love.

The year 1861 was shadowed by a sad bereavement, which caused him the keenest sorrow. He occupied himself still more closely with his official duties, and in the various colonial matters in which he took a part, till, in 1870, he retired from the Observatory, and lived at his residence in Mowbray, about a mile from the scene of his former labours. Latterly his sight failed him, and in 1876 he became totally blind. In his declining health he was tenderly nursed by a devoted family; he kept up his interest in science and politics with unabated vigour, his daughters reading to him for hours together. He was particularly interested in all matters connected with the exploration of Africa, and the last occasion on which he left his house was to attend a meeting held in Cape Town when Stanley visited the colony.

No name was better known or better loved in the colony than that of Sir Thomas Maclear. On the occasion of his last public appearance, which we have just mentioned, he was received with even greater applause than that which greeted Stanley himself.

Sir Thomas Maclear gently breathed his last on July 14, and his remains were interred in the Observatory grounds beside those of his wife, not far from the spot where Fallows—the first astronomer at the Cape—is buried.

Sir Thomas Maclear was elected in 1828 a Fellow of this Society; in 1831, a Fellow of the Royal Society; in 1835, a Member of the Academy of Sciences, Palermo; in 1858, a Corresponding Member of the Imperial Geological Institution

and Geographical Society of Vienna; and in 1863, a Corresponding Member of the Institute of France. In 1860 he received the honour of knighthood, in 1867 he received the Lalande Prize of the Institute of France, and in 1869 a Royal Medal of the Royal Society.

The House of Assembly at Cape Town agreed to the following resolution on July 17, 1879:—"That this House desires to express its deep sense of the signal services rendered by the late Sir Thomas Maclear, Knt., F.R.S., F.R.A.S., to the general cause of astronomical and geographical science while in charge of the Royal Observatory, Cape Town, and also to the material interests of the colony in the practical application of his researches; and, furthermore, its high appreciation of his devotion for a long period of years to the cause of South African exploration and civilisation; and that this resolution be recorded in the journals of the House."

Henry Mann, late of Spern Bank, near Cleckheaton, died at 15 Phillimore Gardens, Kensington, on August 20, 1879, aged 73. He was attached to astronomy, and possessed a valuable instrument; he was also a distinguished amateur musician. He was elected a Fellow of the Society on May 12, 1871.

John Netwon Peill, B.D., was born at Liverpool on December 14, 1808. He was educated at the Royal Institution in that town, and afterwards at Queen's College, Cambridge. He graduated as Seventh Wrangler in the Mathematical Tripos, 1831, and was soon after elected a fellow of his college, of which he became also tutor and bursar. He was rector of St. Botolph's, Cambridge, from 1843 until 1853, when he was presented by his college to the rectory of Newton Toney, in the diocese of Salisbury. He became also rural dean of Amesbury, and diocesan inspector of schools. A most active and energetic clergyman, he was well known for his administrative abilities, especially in connection with schools for the poorer classes. He possessed some good astronomical instruments, and made many observations in his little country Observatory, but the mathematical side of astronomy had for him the most interest. He died on June 12, 1879. He was elected a Fellow of the Society on January 12, 1869.

John Edmund Richard was the son of John Richard, of St. Martin's Lane, and was born in London in 1818. He received the greater part of his education privately, and early in life joined his father in the old-established firm of Richard & Wilson, wholesale stationers, St. Martin's Lane, London. Mr. Richard's love of scientific pursuits was manifested in his younger days, and he appears to have dipped into most sciences; but circum-

stances having thrown him much into the society of astronomers, he for many years took up that branch of science as his favourite recreation. He built himself an observatory in the grounds surrounding his house at West Hill, Wandsworth, and furnished it with one of Cooke's Equatoreals and a Transit Instrument by Simms. Here he carried on a series of observations which probably were known to but few even of his intimate friends, his retiring nature preventing him from giving that publicity to his works which some of them deserved.

His delight was to surround himself with men interested in science, and his great hospitality and warm-heartedness were of assistance to many. He enjoyed the satisfaction of seeing a family grow up around him who took great interest in their father's scientific pursuits. He died on October 24, 1879, after an illness, not of long duration, but of intense suffering. He was elected a Fellow of the Society on June 10, 1859.

John Waterhouse, F.R.S., was born at Halifax, Yorkshire, on August 3, 1806.

His father, John Waterhouse, of Well Head, was the representative of a family which, for 400 years, had been intimately connected with the prosperity of the town and neighbourhood.

Very early in life he evinced a decided taste for scientific studies, and the training which he received at school only served to increase this preference, and enabled him to obtain a sufficient knowledge of mathematics, which he turned to good account in after years in the various branches of physical research to which he gave attention.

A certain weakness of constitution, which prevented him in his youth from great physical exertion, only seemed to stimulate his mental activity; and when, in search of change of climate with a view to invigorated health, he undertook a voyage round the world, the training which he had received and the bent of his mind enabled him to record his observations in a journal which is a storehouse of scientific facts and notices, and which, had not his modesty shrunk from having it printed, would have proved the record of a "scientific expedition" when such journeys were far less numerous and attended by far greater inconveniences than at present. During this voyage his love of nature and the wide range of his scientific tastes acquired an increased stimulus; and when he returned home his experience in observation and his knowledge of natural phenomena in different parts of the world enabled him to enter with renewed pleasure into the less active study of the physical sciences.

He established an astronomical and meteorological observatory, and in connection with the latter published a few years ago a complete work on the "Meteorology of Halifax," which may be regarded as a model for all such local observations.

Practical botany also engaged his attention, and his gardens

were distinguished throughout the neighbourhood for the rich variety of their contents, of which he was justly proud.

His favourite studies were astronomy, geology, electricity, and light, and in connection with the latter he was identified with the early progress of Photography, and with the discovery by the Rev. J. B. Reade, F.R.S., of the method of taking portraits, first upon leather and afterwards upon paper, instead of upon silver plates or glass, and also with the chemical means of giving permanence to such images.

He was also specially interested in the progress of microscopy, and was himself both a skilful observer and an adept at those manipulations which are necessary in the preparation of objects for examination. He was also extremely fond of music, and was a skilful performer on the violoncello. Indeed, he seemed able to turn his hands to any pursuit, and such was the aptitude which he possessed for grasping the general principles upon which any practical operation depended, that he speedily was enabled to do with proficiency work which required under ordinary circumstances years of patient labour and practice. Few men could handle their tools better than he could; for, in addition to his scientific acquirements, he was a good mechanician, and many of his turnings in ivory were almost unrivalled for their beauty and skilful execution.

Those who knew him best can best appreciate the many-sided features of his genius, and will long remember the evenings spent at Well Head, where, although reticent in public, he would converse with ease upon the various departments of mathematical or physical investigation with an originality of illustration which showed that he was practically, as well as theoretically, acquainted both with the facts and principles of science.

As might be expected, he was also identified with those movements which had for their object the spread of scientific knowledge; and, in connection with the local Literary and Philosophical Society (of which he was one of the founders and for many years the president), he lectured on more than one occasion on various scientific subjects. He also enriched the museum with many choice objects of natural history, collected during his travels.

He was also connected with the Mechanics' Institute during its early years, and was active as a magistrate, being for many years Chairman of the County Bench at Halifax, and a deputy lieutenant for the West Riding.

In later years a stroke of paralysis, which compelled his retirement into private life, only made him appreciate his gardens the more, until a severer form of his malady prevented all mental pursuits, and finally terminated his life on February 12, 1879, in the 72nd year of his age.

He was a Fellow of the Royal Society, of the Royal Microscopical Society, of the Geological Society, and several others.

Although a certain timidity of disposition prevented him from making original discoveries, few men were better acquainted with the whole range of scientific inquiry; and his kind and generous disposition, as well as the means at his command, enabled him to liberally assist many who were pursuing the difficult path of original investigation.

He was elected a Fellow of the Society on May 12, 1837; and at the following meeting on June 9 contributed an account of his observations of the eclipse of May 15, 1836 (*Monthly Notices*, vol. iv., p. 89). This was the only communication he made to the Society.

Samuel Charles Whitbread, F.R.S., of Southill Park and Cardington, in the county of Bedford, Justice of the Peace, was the second son of Samuel Whitbread, M.P., the well-known statesman and adherent of Fox. His mother, Lady Elizabeth, was the sister of Charles, Earl Grey, who was Prime Minister. He was born on February 16, 1796. From 1820 to 1830 he was M.P. for Middlesex, and in 1831 he served as High Sheriff of Bedfordshire. He succeeded to the large landed estates of his family in 1867, on the death of his brother, William Henry Whitbread, M.P., of Southill. On June 28, 1824, he married the Hon. Juliana, second daughter of Henry Otway, twenty-first Lord Dacre, by whom he had one daughter, Juliana, late Countess of Leicester, and one son, Samuel Whitbread, now M.P. for Bedford. His wife died in 1858. On February 18, 1868, he married Lady Mary Stephenson, daughter of William Charles, fourth Earl of Albemarle, who survives him. Mr. Whitbread took considerable interest in astronomy, and built an observatory at his seat at Cardington: a few observations made there were published in the *Monthly Notices*. He was elected a Fellow of the Society on January 12, 1849, and succeeded the late Mr. George Bishop as Treasurer in 1857. This office he held till 1878, when he was reluctantly compelled by the state of his health to relinquish it.

Mr. Whitbread also was one of the three founders of the Meteorological Society in 1850, the late Dr. John Lee and Mr. James Glaisher being the other two. He was always interested in the prosperity of the Society, and a long series of careful meteorological observations were made at Cardington under his direction. He was elected a Fellow of the Royal Society on June 1, 1854.

The brewery, in connection with which the name of Whitbread is so well known, was founded by Mr. Whitbread's grandfather, who is remembered as a benefactor to the town of Bedford.

Mr. Whitbread died at his London residence, 49 St. George's Square, on May 27, 1879. He had been for some time seriously ill, but his death was somewhat sudden.

Professor JOHANN VON LAMONT was born at Braemar, Aberdeenshire, on December 13, 1805. He was the second of three sons, of whom the eldest and youngest are still resident at Goderich, in British North America. After having received his early education at a private school in his native county, young Lamont, at the age of twelve, left his parents' home to become a pupil in the gymnasium attached to the Scotch Benedictine Monastery at Ratisbon, Bavaria, which was established by the monks especially for the education and support of the sons of Scotch Catholics. In this school he was very successful as a student, and generally maintained a foremost place among his fellow-pupils; a position he owed, in some measure, to the interest taken in him by the Prior, Father Deasson, an excellent mathematician and practical mechanician, who was one of the first to notice the talents possessed by young Lamont. After a most regular attendance at the gymnasium for several years, he, in 1824–1826, also passed through the more advanced philosophical and theological courses at the Lyceum with much distinction.

During his career as a student, Lamont had always exhibited a strong inclination for astronomical studies, and it was a great delight to him, in the summer of 1827, to have an opportunity of visiting the Royal Observatory at Bogenhausen, near Munich, then under the direction of Professor Soldner, the Conservator. Soldner was much impressed with the sound knowledge on most astronomical subjects possessed by his young visitor, and this ultimately led to a closer intimacy between them, and to the appointment of Lamont, in March 1828, to the office of Assistant Astronomer at the Munich Observatory. During these first years of Lamont's career as an astronomer, he gave many indications of his future success, and in various scientific journals of the time several astronomical papers may be found on subjects which occupied his attention while an assistant at the Observatory. One of the first, published in 1829, was his note on the observed diminution of the periodic times of Encke's comet. In 1833 he gave an account of the results of his observations of the solar eclipse of July 16 in that year, which was of some interest. On the death of Professor Soldner, in 1833, the office of Conservator of the Munich Observatory remained vacant for some time; and it was not till July 13, 1835, that it was filled up by the appointment of Dr. Lamont, who had virtually the direction of the Observatory after the death of Soldner. In 1852 Dr. Lamont was appointed Professor of Astronomy in the University of Munich.

Though Professor Lamont has been more generally known in the scientific world by his numerous contributions to the theory and observation of terrestrial magnetism, in which he was always considered one of the principal authorities, he never gave up his interest in astronomical observations, which continued to be the standard work of his Observatory during the larger portion of his directorate; the results have been published in

his series of volumes of the *Annalen der Königl. Sternwarte bei München.* In addition to his zone-work, Lamont for many years took a special interest in various miscellaneous subjects of astronomical research, among which may be noticed his long series of observations of Halley's comet in 1835; and, in the following year, of the second and third satellites of *Saturn*—*Enceladus* and *Tethys*—from which he calculated the elements of their orbits. In 1836 he made some measures of *Pallas*, with the object of determining its diameter; and in the same year he undertook an examination of a few of the principal nebulæ and star-clusters, from which he constructed charts of the popular clusters in *Scutum* and *Perseus*. He afterwards published papers on the results of his observations of Moon-culminating stars; on the atmosphere of the Moon; on the rings of *Saturn*; and his important memoir on the mass of *Uranus*, inserted in the *Memoirs of the Royal Astronomical Society*, vol. xi. Professor Lamont's determination of the mass of *Uranus* is based on observations made with the Munich Refractor of 15 feet focal length and 10½ inches aperture, on a few very favourable nights in the autumn of 1837, when he was able to obtain some satisfactory observations of the two outer satellites, *Titania* and *Oberon*. His result, $\frac{1}{24903}$, was not without interest, for it gave a value for the mass of *Uranus* nearly one-fourth part less than that obtained by Bouvard, by the perturbations of *Jupiter* and *Saturn*, which up to that time was generally adopted. Though the value of the mass deduced by Professor Lamont was so much smaller than that previously determined by Bouvard, it was looked upon with some favour as evidence that the mass hitherto in use ought to be diminished, but probably not by so large an amount as that indicated by the difference between the two values. This belief is confirmed by modern investigations. Professor Newcomb's most recent determination, by observations of the two outer satellites in 1874–1875, is $\frac{1}{22738}$.

Professor Lamont was fortunate on several occasions in observing the phenomena visible during eclipses of the Sun, especially in the total eclipses of July 8, 1842, and July 18, 1860, of which he has given interesting detailed accounts. In the *Fortschritte der Physik*, vol. xvi., he has published a valuable *résumé* of all the observations of the eclipse of 1860, made along the shadow-path from the northern to the eastern coasts of Spain, in which the principal phenomena recorded by the different observers are clearly notified, and the general results discussed. Lamont entertained a notion that the red prominences were produced by clouds or other vapours floating in the Earth's atmosphere, and his remarks on the subject give an illustration of the uncertain opinions of astronomers before 1860 as to the physical origin and constitution of these solar appendages. Writing to the Astronomer Royal in the latter end of 1859, Lamont remarked: "I suppose them to be produced by thin clouds, or masses floating in our atmosphere and condensed by

the depression of temperature in the shadow of the Moon." The eclipse of 1860 was favourably observed by him at Castellon de la Plana, and in his *résumé* of the observations Lamont refers to this opinion as one no longer tenable: "With regard to the hypothesis advanced by myself that the colours of the protuberances are produced by inflexion of light at the Moon's limb, and their forms by small masses of vapour floating in our atmosphere, this has been set aside by the circumstance that the same protuberances were seen at different places. Nevertheless, I cannot yet entirely give up the opinion that the vapours of an atmosphere—that is, the condensations caused by reduction of temperature next to the inmost shadow—do exercise a very considerable influence upon the phenomena of total eclipses, and especially upon the forms of the protuberances."

In 1840 a very important international system of magnetical observations was organised, and Professor Lamont, who had previously established a magnetical Observatory, entered into the scheme with great earnestness and zeal, and his experience and counsel were found to be of considerable service in arranging the plan of observation. The question was taken up with energy by the Council of the Royal Society, who appointed a strong committee of English physicists, by whom a series of elaborate instructions were drawn up for the guidance of the observers, and to insure order and regularity in the observations. The Government had previously sanctioned the equipment of an Antarctic expedition for scientific objects, under Captain James Clark Ross, and, in connection with this expedition, the establishment of Observatories in different parts of the globe for the special observation of magnetical and meteorological phenomena. The observations were simultaneously made at all the stations, the time chosen being the commencement of each two-hourly interval during the twenty-four hours, Göttingen mean solar time. No one took a greater interest in the success of this great scientific expedition than Professor Lamont, whose co-operation in the undertaking proved to be of great value. His own observations during the first three years of the experiment are contained in the *Abhandlungen* of the Munich Academy of Sciences, vol. iii., 1837–43.

In the *Catalogue of Scientific Papers* the titles of 107 separate investigations, distributed in various scientific publications, are attached to the name of Professor Lamont. These, however, take no account of the successive volumes of the *Annalen* and their contents. The greater number of his miscellaneous papers are devoted to magnetical or meteorological researches, but the record of astronomical work in the *Annalen* is a sufficient proof that practical astronomy was not neglected at the Munich Observatory. Lamont's first magnetical paper whose title is recorded in the Scientific Catalogue is *Bestimmung der Horizontal-Intensität des Erdmagnetismus nach absolutem Maase*. This contribution to an almost new science was followed by a long series

of miscellaneous researches on magnetical and meteorological observations and instruments, all of which bear the marks of his great experience. He has also published an exhaustive treatise on the science, which has gone through several editions, the last of which appeared in 1867 under the title of *Handbuch der Magnetismus.*

Though the name of Professor Lamont may be best known to posterity in association with magnetic science, it must also be permanently connected with the history of astronomy of our time by the excellent series of zone-observations of telescopic stars carried out under his direction at the Munich Observatory. This valuable collection of reduced mean places of small stars is contained in six volumes, published as supplements to the *Annalen der K. Sternwarte*, in which the original observations are given in successive volumes. The total number of stars observed are 34,674, contained in ten catalogues, each extending over a zone of six degrees of declination, and a supplementary catalogue containing stars accidentally omitted in their proper zone. The portion of the heavens included in this survey of Lamont extends from 27° north declination to 33° south declination; but his principal attention was given to the stars in the five zones between $+15°$ and $-15°$, nearly five-sixths of the whole being included between these parallels. The resulting mean right ascensions and declinations are reduced to 1850. We have found, from a comparison of the mean places of several corresponding stars in the Munich and Greenwich Catalogues, that they agree generally within reasonable limits, and thus for most purposes we believe that the Munich places may be adopted with confidence. Professor Lamont has himself compared his catalogues with those of Lalande, Bessel, Rümker, and Schjellerup, and the differences between the corresponding right ascensions and declinations are inserted in the zone catalogues. Excepting in cases where there is an evident error in the observations, these differences appear to be as small as might be expected, considering that a large number of the places of the stars depend on one observation. The stars observed are all invisible to the naked eye, being of the eighth and ninth magnitudes, with a few of the tenth. The insertion of the magnitudes of so many telescopic stars may occasionally be found useful in investigations on the periodicity of variable stars, and the whole work is a valuable supplement to the more extensive zone-observations of Argelander and Bessel. The six volumes were published in different years, the first in 1866 and the last in 1874.

In the *Monthly Notices*, vol. x., p. 42, Mr. Hind points out that the planet *Neptune* was unconsciously observed at Munich as a star on two occasions—on October 25, 1845, in zone 338, and on September 7, 1846, in zone 379—before its discovery by Dr. Galle. The apparent R.A. and N.P.D. of *Neptune* for these days were deduced by Mr. Hind from a comparison of the observed positions of the planet with those of several of the brighter stars

in each zone whose places had been determined at Greenwich or the Cape.

Professor Lamont was a member of most of the principal Scientific Academies and Societies of Europe. In 1852 the Royal Society elected him a Foreign Member, and he was connected with our Society, as one of its Associates, from May 12, 1837. His scientific services were frequently honoured by Foreign Governments, from which he received various orders of knighthood. He died at Munich on August 6, 1879, at the age of seventy-four.

E. D.

Proceedings of Observatories.

The following Reports of the proceedings of Observatories during the past year have been received by the Council from the Directors of the several Observatories.

Royal Observatory, Greenwich.

The Transit-Circle and Altazimuth have been used regularly, as in past years, for observing the Sun, Moon, planets, and selected stars. Much attention has also been given to occultations of stars by the Moon and phenomena of *Jupiter's* satellites. To facilitate these observations the "Naylor" 6-inch Equatoreal by Cooke, returned from the late Transit of *Venus* Expedition, has been recently mounted in the grounds, for use when the Great Equatoreal is not available. A new determination of the flexure of the Transit-Circle telescope was made in April 1879, which gave the value $+0''.16$, whilst that hitherto adopted was $-0''.13$. Under these circumstances no flexure correction has been applied to the observations since the beginning of 1879. In connection with the question of refraction, to which allusion was made in the last report, thermometers have been mounted in various parts of the Transit-Circle room, and in the front court, at some distance from the buildings, in order to obtain data as to the temperature of the air in the neighbourhood of the instrument. Mention has been made in a former report of the observation of stars by reflexion in R.A. A discussion of the results for 50 stars, thus observed in 1878, shows that there is no sensible error in the adopted level corrections.

A complete discussion of the observations of the Moon's diameter in azimuth and zenith distance, with the altazimuth from 1864 to 1878, has been made by Mr. Lynn. This shows the existence of large personalities, and it is therefore proposed in future to use for each observer the value of the diameter deduced from his own observations, the probable error of the result being, as a rule, but a small fraction of the differences between different observers.

With the Great Equatoreal a few micrometer measures of *Saturn's* satellites, of the outer satellite of *Mars*, and of the red spot on *Jupiter* have been made, as also several sketches of *Mars* and *Jupiter*.

Some extensive alterations were made in the Great Equatoreal in the spring of last year, to make it more conve-

nient for use with the long half-prism spectroscope. With this object the telescope tube was shifted longitudinally 30 inches, bringing the eye-end nearer to the centre and allowing more room between it and the floor, and some other changes were made. The spectroscopic observations suffered some interruption in consequence, and were not actively resumed till the summer. The chromosphere was examined on 27 days (between 1879, June 30, and 1880, January 31), on four of which no prominences were seen. Three of these days, however, were very unfavourable for observation. The spectroscopic determination of star motions in the line of sight was resumed at the end of last May, but again intermitted during the opposition of *Mars*. Measures of the displacement of the F or *b* lines have been made in the case of 28 stars, 8 of which had not previously been examined. Up to the present time 63 stars have been thus observed at Greenwich; and as it is found practicable with the half-prism spectroscope to measure the displacement in the case of stars of the fourth magnitude, it is expected that in course of time the motions of some 300 stars may be determined by Dr. Huggins' method. For the present a working list of 150 stars has been formed.

The Sun-spot of 1879, August 27–September 8, Brorsen's comet, and the two components of μ *Draconis* have been spectroscopically examined.

During the year 1879 photographs of the Sun were taken on 128 days; on 83 there were no spots, and on 63 no faculæ. The last four months of the year show a remarkable increase in the number of spots and faculæ as compared with the beginning of 1879, and it is evident that the Sun-spot minimum is now passed. This is shown clearly in the Tables of "Means of daily areas of Spots and Faculæ," 1873 to 1879, communicated to the Society. The photographs have been measured in duplicate up to the end of 1879, and the measures completely reduced. The copy for press, 1879, has been prepared, and is now in the printer's hands.

All the reductions are in a forward state. The altazimuth, spectroscopic, and photographic observations are completely reduced to the end of 1879, and the corresponding MSS. have been sent to the printer. The volume for 1877 has been distributed, as well as separate copies of the Introduction and Results.

The Observatory has to regret the loss of the services of Mr. Lynn, who has at length been compelled by ill-health to resign his post. His successor has not yet been appointed.

The meteors of August (the Perseïds) were well observed; the circumstances at the period of those of November (the Leonids) were exceptionally good, but few meteors were seen. The anticipated Biela's comet shower was carefully watched for on November 27 and 28, but no meteors were seen; the sky was

generally clear on the nights mentioned, but otherwise the circumstances were very unfavourable, owing to the presence of a bright full moon.

Cambridge Observatory.

The astronomical work of this Observatory is still almost exclusively devoted to the zone observations. Notwithstanding the exceptionally unfavourable weather during the past year, 3,220 observations of zone stars, 605 of standard stars, and 132 of *Polaris* have been made with the Meridian Circle.

The total number of stars in the zone is 10,299; of these 6,677 have now been observed three or more times, 1,114 stars have been observed twice, 1,316 once, and 1,192 stars are unobserved. In order to complete the zone observations so that each star shall have been observed at least three times, 7,322 observations are still required.

The Nadir Point is observed almost invariably at the close of each night's work, and also after the observation of *Polaris* when taken by day; there are thus 214 observations for Nadir Point, 191 for collimation, and 147 for level.

A careful watch for *Vulcan* was kept up on March 19, as long as the Sun was above the horizon, but without any result.

Very satisfactory observations of the occultation of *Antares* on July 28 were made by two observers independently of each other. The observed times were almost identical.

A redetermination of the value of one revolution of the N.P.D. Micrometer of the Transit-Circle gave very nearly the same result as that which has been used hitherto.

			r	
10 differences with the W. circle give			1	= 37·066
10 „	„	E. „	„ 1	= 37·058
			Mean	37·062
The value used hitherto is				37·058

The pivots were re-examined from June 9 to 14 at circular intervals of 30°. The instrument was turned 10 times round and the horizontal coordinates of the dots observed, and again 10 times round and the vertical coordinates observed. On the 9th and 10th of June the observations were made by daylight, an observer being at each end of the axis; but the light was not good, and the observations, especially of the east pivot, were unsatisfactory. After several trials, a mode of illumination by means of the axis lamp and lens was devised which showed the dots and circle beautifully. After this, on June 13 and 14, 480 measures of coordinates were taken by a single observer so as to make the results as far as possible homogeneous and reliable, and

24 measures of the diameter of each small circle on the end of the pivot were also made, to obtain the value of 1 revolution of each micrometer. The measured coordinates were reduced to a mean centre for each pivot, and the deviation of the instrument eastward from the meridian, consequent on the inequalities of the pivot, were calculated for the 12 symmetrical positions of the instrument at which they were observed.

Putting e for the deviation, in units of $15''$ of arc, and z for the zenith distance, these 12 deviations are accurately represented by the circular function,

$$e = \cdot0063 \sin(213^\circ\,57' + z) + \cdot0050 \sin(32^\circ\,44' + 2z) + \cdot0050 \sin(49^\circ\,54' + 3z) + \cdot0055 \sin(58^\circ\,46' + 4z) + \cdot0013 \sin(131^\circ\,59' + 5z) + \cdot0024 \sin(90^\circ + 6z)$$

or, in terms of the North Polar Distance (Δ),

$$= \cdot0063 \sin(176^\circ\,10' + \Delta) + \cdot0050 \sin(317^\circ\,10' + 2\Delta) + \cdot0050 \sin(296^\circ\,33' + 3\Delta) + \cdot0055 \sin(267^\circ\,37' + 4\Delta) + \cdot0013 \sin(303^\circ\,3' + 5\Delta) + \cdot0024 \sin(223^\circ\,17' + 6\Delta)$$

On June 28 a series of bisections were made with the centre wire on the north and south collimators, first moving the R.A. wire toward the micrometer-head, and afterwards moving from the micrometer-head to make the bisection. The mean of 20 observations each way gives, for wire moved

	r
Toward head	0·1157
From ,,	0·1164

The S. collimator was very unsteady; yet the results seem to prove conclusively that it is indifferent which way the Micrometer is turned in making the bisection.

Between August 6 and 11 a series of observations were made in order to find the corrections to be applied to certain arcs as determined by the west or fixed circle in consequence of errors of division. The readings were compared with those of the east or movable circle in six different positions of the latter with respect to the telescope tube, the circle being turned through 15 degrees in passing from one position to the next. The final results are:

Correction of Arcs determined by W. Circle on account of Errors of Division.

	″
From N. Pole to Zenith	−0·16
,, Zenith to 55° N.P.D.	+0·29
,, ,, to 0° ,,	+0·36

The coefficient of flexure for the tube of the Transit-Circle was carefully determined by direct observations of the collimators, made on sixteen separate days, from August 23 to September 9. The result is that, if we assume the correction for flexure to be as the sine of the zenith distance, the observed zenith distances, southward, are too great by

$$(0''.936 \pm 0''.024) \sin z.$$

It was assumed that the bend of the telescope is the same whichever side is uppermost.

To test the efficiency of the protection afforded by the covering of the telescope from the heat of the observer's body in taking the Nadir Point, observations were made on September 12, 13, 15. The results indicate that the Nadir Point taken with the observer on the S. side of the tube exceeds that taken with the observer on the N. side by

$$0''.3067 \pm 0''.0190.$$

With regard to the difference resulting from the direction in which the telescope is turned on the Nadir, the observations on September 13 and 15 render it probable that the Nadir Point, when the instrument is turned from the S. horizon, exceeds that obtained when it is turned from the N. horizon by

$$0''.076 \pm 0''.033.$$

To ascertain whether the instrument is injuriously affected by the ropes used for setting in the zone observations, it was put in harness on October 1, and three determinations of the Nadir Point were made with the ropes quite as tight as they ever are when used for setting the instrument in ordinary zone work, and three with the ropes quite slack. The mean of the results for Nadir Point gave, for

	°	′	″
Ropes tight	337	47	25·40
,, slack			25·42

which seem to indicate that discrepancies in zenith distance are not to be attributed to this cause.

A discussion of the N.P.D. of *Polaris*, obtained from the observations by the Transit-Circle in 1878 seems to show that the Berlin declination, as given in the Catalogue of 539 Stars, is too great by $0''.73$, or, as corrected by the Zone Committee, it is too great by $0''.36$, and that the *Nautical Almanac* declination is too great by $0''.32$.

It seems to show, moreover, that the assumed co-latitude of the Cambridge Observatory ($37° 47' 8''.4$) ought to be increased by $0''.46$, making it

$$37° 47' 8''.86.$$

In confirmation of this, it may be worth mentioning that a

careful reduction and examination of the standard clock stars, assuming the *corrected* Berlin places to be true, gives for the co-latitude

° ′ ″
37 47 9·02.

Vol. xxi. of the *Cambridge Observations* is now completed, and a large number of copies have been distributed.

Radcliffe Observatory, Oxford.

Mr. Stone arrived in England to take charge of the Observatory at the end of June 1879.

The staff then consisted of only one assistant, Mr. Bellamy, whose time was chiefly occupied in making and reducing the regular meteorological observations and observing stars for clock-error. The staff has since been completed by the appointment of Mr. A. Bowden, as First Assistant, and Mr. Robinson as an assistant.

The position-circle of the Heliometer has been redivided by Mr. Simms, and the instrument cleaned and put in good working order. The cloudy weather which has prevailed at Oxford throughout the year has prevented much work being done with the instrument, but some measures of the diameters of *Mars* have been made, and the distances and positions of some double stars have been measured.

The Transit-Circle has been cleaned, readjusted, and the tube strengthened, and a large number of reflexion observations made to determine the amount of a systematic discordance which existed between the nadir point determinations. A large discordance of about 1″·5, which has existed between the nadir point determined by the reflecting eye-piece and from reflexion observations of stars, since the erection of the instrument at Oxford, was a source of continual anxiety to Mr. Main.

These discordances appear now to have been traced to their sources and reduced to small limits, if not entirely removed.

It is intended to employ the instrument, amongst other work, upon regular observations of the Moon. These observations have been rather neglected of late years, except at Greenwich, and, now that questions of apparent changes in the mean motion are raised, it is certainly desirable that the discussions should not depend upon the work of a single instrument.

The Photographic Meteorological Instruments, which had been working continuously since 1854, required extensive repairs, and a modification of the exposure of the thermometers was certainly necessary. It has therefore been thought better to replace the old instruments by a new set, on the Kew pattern, which have been kindly lent for the purpose by the Meteorological Commission.

The new instruments have been brought into regular work. It is hoped that these instruments may be kept in use for two years; but if a comparison of the diurnal and annual changes thus obtained should generally confirm the old results, it is doubtful whether photographic registration should be permanently continued with the present staff of the Observatory.

The Catalogue of stars for 1866, from observations made 1862–1870, which was left in an advanced state at the time of Mr. Main's death, is approaching completion. The precessions and secular variations for all the stars contained in the Catalogue which had not been recently published elsewhere have been computed since last June, and there only remains the general revision of the work for the detection of errors and the preparation of an Introduction.

The Eye Meteorological Results for 1876, 1877, 1878, and 1879 are nearly ready for press, and will be included in a single volume.

The Cape Catalogue, 1880.

With the exception of the Introduction, the work has been completed and revised for press.

The sheets containing the positions of 4,320 stars have already been passed through the press. The total number of stars contained in the Catalogue is 12,438.

The examination of the work and the reading of the proof sheets has occupied, and must continue for some time longer to occupy, a very considerable portion of Mr. Stone's time.

The Oxford University Observatory.

The astronomical work undertaken since the last Annual Report, at this Observatory, is as follows:—

I. Observations of the following comets: Tempel, 1867, II., Swift, Brorsen, Hartwig, and Palisa.

II. A third set of the relative positions of 40 stars in the *Pleiades* with the duplex micrometer. These are now reduced to the Mean Equinox, 1879, and it is hoped that the results will be communicated to the Society, together with a description of the new micrometer, which has been successfully used in these observations. The rigorous reductions have been found troublesome, on account of the unusual largeness of the arcs measured, amounting in some instances to 20′.

III. Three observations of the outer satellite of *Mars* have been obtained with the large Refractor. It seems likely that such observations may be profitably discontinued with telescopes not of extraordinary aperture.

IV. Observations of the length of the shadows of lunar

mountains, for the purpose of comparison with those given in lunar photographs taken at corresponding times.

V. The relative positions of about 250 stars in the group Messier 39, in *Cygnus*, are in course of observation with the De La Rue Reflector and a modified adaptation of the Bar Micrometer. It was soon found that these observations required an undesirable stress of mind in observing the times of the transits of these very contiguous stars, to obviate which a form of chronograph has been devised specially adapted to this particular purpose. It is very inexpensive and sufficiently effective. This little instrument will be exhibited at the next meeting of the Society.

VI. The series of lunar photographs has been maintained, but the number has been reduced.

VII. Measures of the diameters of these lunar photographs have been taken and reduced, with the view of testing what amount of reliance can be placed on photographic measures generally. The results appear to justify the necessary reliance. Some of these results have been submitted to the Society. The calculations for the determination of the selenocentric coordinates are proceeding, preliminary to the formation of the equations of condition, the solution of which will tend to decide the fact of a lunar physical libration or otherwise.

VIII. For the more immediate purposes of the educational work which forms part of the business of the Observatory, a set of models of Ptolemy's instruments has been constructed. A convenient form of precessional celestial globe has also been devised for the mechanical solution of remotely ancient stellar phenomena of configuration at any place on the Earth.

The Observatory, Dunsink, Co. Dublin.

During the past year a set of observations for the annual parallax of 61 (B) *Cygni*, by the method of differences of declination, has been completed. Observations were made on 38 nights since September 18, 1878.

A series of observations for the annual parallax of Groombridge 1618 has also been completed. This series commenced on March 4, 1878, and the distance and position angle of the neighbouring star $+50°$, 1724 has been measured on 59 nights. A second series of measures of this object was commenced last autumn and is now in progress.

Observations of the star P. III. 242 recommended as a suitable parallax object by O. Struve (*Monthly Notices*, vol. xx., p. 8) were commenced in January, and were almost completed at the close of the year.

Parallax observations of the red star Schjellerup 249 (a) ($= +34°$, 4500) were commenced in October and are at present in progress.

A large number of observations in search of stars with large parallax have been made. The method adopted is described in Part III. of the *Dunsink Observations*, which has been recently issued.

It is expected that Part IV., containing the meridian observations of red stars, will be ready for press in the autumn.

Royal Observatory, Edinburgh.

The ordinary daily business of this Observatory has been going on as usual during the past year. Observations for time, and its daily distribution by ball, gun, and controlled clocks, have been attended to as regularly as ever; and the meteorological observations at 55 of the stations of the Scottish Meteorological Society have been computed and discussed for the Registrar-General in Scotland, and printed by that officer in his monthly and quarterly returns. The credit for all this work is chiefly due to Mr. Alexander Wallace, M.A., First Assistant, and Mr. Thomas Heath, B.A., Second Assistant.

The deep-rock thermometers, so calamitously destroyed in 1876, have, after long and careful remaking and preparation, been successfully replaced during the last year by Mr. Wedderburn, of Messrs. Adie & Son; they are again therefore under regular observation, and are to be reported on to Government next June, according to the contract terms.

Glasgow Observatory.

The operations at the Glasgow Observatory during the past year have been mainly devoted to the completion of a Star Catalogue which is intended to embrace all the star observations made with the Transit-Circle at the Observatory during the period 1860–80. The number of stars is 6,350, ranging chiefly between the sixth and ninth magnitudes. The epoch of reduction is 1870. The place of each star is in general determined by at least three observations. Steps have been taken to have the Catalogue printed.

The transmission of Greenwich time to the city and port of Glasgow by the electrical control of clocks, which was originally introduced at the Observatory in 1863, has been in active operation during the past year.

Kew Observatory.

The astronomical work of this Observatory has been confined during the past year to the completion of the measurements of

the ten-year sun-pictures, as noticed in the last report, and to the preliminary reductions of $\frac{r}{R}$ as far as August 1871 of the above measurements, which has been carried on at Mr. De La Rue's expense and under his direction.

It is expected that the above preliminary reductions will be completed in the course of two or three months.

The reduction of the measurements to heliocentric elements has been continued by Mr. Marth for Mr. De La Rue.

The eye observations of the sun, after the method of Hofrath Schwabe, as described in the report for 1872, have been made on 151 days, in order to maintain for the present the continuity of the Kew records of sun-spots. The sun's surface was observed to be free from spots on 113 of those days.

The Campbell Sunshine Recorder continues in action, and the instrument in its improved form, giving a separate record for every day of the duration of sunshine, has been regularly worked throughout the year and its curves tabulated.

Two papers based upon these records have been read by the Superintendent before the Meteorological Society and published in their quarterly journal.

The magnetical and meteorological work, to which the attention of the Observatory is chiefly directed, has been prosecuted continuously, and the Verification Department has been fully occupied the whole year.

Liverpool Observatory, Bidston, Birkenhead.

The object for which this Observatory was originally established has been steadily kept in view.

In 1873 a formula was published by the Mersey Docks and Harbour Board, at the recommendation of the Marine Committee, for calculating the corrections to be applied to the rates of chronometers under varying influences of temperature. Upwards of three thousand chronometers have been tested at this Observatory in such a way as to supply the necessary data for making these calculations. It has, however, been found necessary, in order to meet the requirements of the mariner, to furnish him with the calculated rates for the various temperatures to which his ship is likely to be exposed and to supply him with the means of keeping a systematic record of the performance of his chronometers at sea. At the request of the Directors of the "Pacific Steam Navigation Company," this has been done for their officers during the past two years with the most satisfactory results. The ships belonging to this Company carry three chronometers each, which may be called a, b, c. The rates of these instruments are supplied from this Observatory for every 5° of Fahrenheit from 45° to 95° inclusive. By means of these rates the Greenwich time for each chronometer is obtained daily by merely

adding the rate for the observed temperature to the error of the instrument for the preceding day ; *a* is then compared first with *b* and then with *c*. In this way the differences of Greenwich mean time between *a* and *b* and between *a* and *c* are found daily, both by calculation and by comparison with each other. The whole of this process is only the work of a few minutes, and a record of the Greenwich time and of the performance of the instruments relatively to each other is preserved for future reference. The Mersey Docks and Harbour Board have recently ordered to be printed and distributed amongst mariners an example showing the daily performance of three chronometers in one of the Pacific Steam Navigation Company's ships during a voyage of 107 days. This ship crossed the Equator twice, and twice passed through the Straits of Magellan, and the error of longitude by the mean of the three chronometers appears to have scarcely exceeded two or three miles at any time during the voyage. In order to show that this is not an exceptional case, a table follows, which gives the error of longitude as shown by the chronometers for each of twenty voyages of the Pacific Steam Navigation Company's ships, taken in succession ; these results having been obtained in the same way as shown in the example given in detail.

The mean error of longitude from these twenty voyages is $5\frac{1}{2}$ geographical miles on the Equator for an average voyage of 102 days ; for ten of the twenty voyages the largest error is under $4\frac{1}{2}$ miles ; for eighteen of the twenty voyages the largest error is under 9 miles, and for two voyages the errors are $17\frac{1}{2}$ and 18 miles respectively. The last two errors were produced by an unusual change of rate in one of each three chronometers ; by rejecting these two instruments, and taking in each case the mean of the other two, the error of longitude is $1\frac{1}{2}$ instead of $17\frac{1}{2}$ miles for one ship, and 8 instead of 18 for the other. By using one uniform rate in variable temperatures a considerable majority of the timekeepers may be influenced in the same direction ; but when the rates are corrected for change of temperature, the variations arising from other causes have a tendency to neutralise each other. Of the twenty voyages with three chronometers in each ship, there are ten in which the timekeepers put the ship to the east on the average four miles, and ten which put the ship to the west on the average seven miles. These are the averages of the accumulated errors for voyages of from three to four months' duration. The errors of the chronometers on Greenwich time are generally checked two or three times during each voyage, and the results entered in the error and rate book. The records contained in these books, together with the rates obtained at the Liverpool Observatory in definite temperatures, supply a continuous record of the performance of each timekeeper, and the data thus obtained are used in the calculations for predicting the most probable rates. By means of three fairly good chronometers treated in this way,

the Greenwich time at sea is known from day to day with a degree of accuracy which, without an examination of these records, might appear incredible.

From the performance of the chronometers employed in the twenty voyages before named, it appears that the average error due to change of temperature between 45° and 95° Fahrenheit is $2^s{\cdot}8$ a day; but when corrected for change of temperature the average error for three chronometers on the sea voyage is only $0^s{\cdot}22$ a day. It might therefore be reasonably expected that, by correcting the rates for change of temperature, a great improvement would be effected in the method of finding the Greenwich time at sea by means of chronometers.

Stonyhurst Observatory.

The large automatic spectroscope by Browning, which was in course of construction last year, has been completed, and is now in daily use at the Observatory. The instrument consists of six prisms of 60°, the light passing twice through each prism. As any number of the prisms can be employed, and the number changed without loss of time, an object may be very readily examined with different dispersive powers. The power generally used in the daily observation of the chromosphere is that of eight prisms of 60°, but a single prism twice used suffices to show the prominences. The adapter of the spectroscope is furnished with a pair of screws by which the slit of the instrument can be placed either radially or tangentially on any part of the edge of the Sun, whilst the centre of the Sun remains at the middle of the field of view of the telescope; and then, by aid of rack and pinion, the slit can be swept round the solar limb without altering the position of the Equatoreal. The spectroscope is provided with a micrometer for measuring the distance of the lines of the spectrum; but it became at once obvious that the only practical way of observing the varying height of the chromosphere is by the use of a photographic scale of tenths of millimetres, the readings being taken to hundredths. The slit carried by the collimator is 2·5 millimetres in length; but the extraordinary height of some of the solar prominences has rendered it necessary to provide a second slit in which the length is less limited, but in which the definition may not be quite so perfect throughout. A small photographic camera is adapted to the spectroscope. The instrument arrived at the Observatory at the beginning of March, but, as several changes were found necessary in the adapter, it was finally completed only in the month of October.

In November and December the chromosphere was mapped on 18 different days, showing that a very fair amount of this work can be effected even during the winter months.

The observations of *Jupiter's* satellites, of occultations of stars by the Moon, and of meteors, have been carried on as usual,

but the double star measures have been less numerous than in preceding years.

No change has been found necessary in the meteorological and magnetic branches of the establishment. A full discussion, undertaken here, of the meteorological observations made at Kerguelen Island on the occasion of the Transit of *Venus* Expedition in 1874 has just been published by the Meteorological Office.

Temple Observatory, Rugby.

The work of the Observatory during the year 1879 has been the continuation of the measurement of positions and distances of double stars. The opportunities have been few after deducting the time given up to school work, but 342 complete sets of measures have been made by Mr. Seabroke, Mr. Percy Smith, and Mr. Hodges, each set of measures consisting generally of four measures of position and two double measures of distance. Each star, with few exceptions, has been observed on three different nights.

The spectroscope on the 12-inch Reflector has been used for the measurement of the motion of stars in the line of sight, and the results, together with those of former years, have been brought before the Society.

The usual attention has been given to the use of the Observatory for educational purposes.

Mr. Barclay's Observatory, Leyton, Essex.

The large Refractor has been employed during the past year in a continuation of the measures of double stars commenced here some years since, and the satellites of *Saturn* have been observed when possible, Mr. Marth's ephemeris being used for identification.

The number of cloudy nights has been unusually large, and the meridian observations of the Sun fewer than in almost any preceding year.

Mr. Common's Observatory, Ealing.

In August last a 36-inch Equatoreal Reflector was completed and is at work. The definition is quite equal to the 18-inch erected in 1876; the mirrors of both instruments were made by Mr. Calver, the mountings by Mr. Common himself.

On September 21 *Deimos* was found, and the principal work done since has been observing *Deimos*, as well as the inner satellite of *Mars*. *Mimas* and *Hyperion* have also been well seen.

When convenient the power of the mirror has been tested photographically with the following results :—

With *Jupiter* an exposure of 1^s to 2^s gives a strong image with some little detail; the red spot coming out well, as also the darkening towards the north pole. The satellites give a dense image in 20^s, and it was found that, by placing a bar over *Jupiter* and exposing the satellites for 15^s to 20^s and withdrawing the bar about $1\frac{1}{2}^s$ before the finish of the exposure, the planet and satellites could be got on one plate in their proper places.

Saturn and *Mars* were photographed in from 5^s to 8^s, but without any appreciable detail, except, perhaps, in the case of *Saturn*.

With the Moon the exposure cannot be made by hand with sufficient quickness, and some mechanical means will have to be used.

An attempt was made by exposing for 20^m to get a picture of the nebula of *Orion*, but without success. When an electrical control is completed to the driving clock a longer exposure will be tried.

Two plates of the *Pleiades* have been taken, showing all, or nearly all, the stars given in the maps of this cluster, with $1\frac{1}{2}^m$ exposure, the three faint stars near *Alcyone* showing plainly.

The great amount of light tells very much on the fainter nebulæ, and several have been seen that are not in Herschel's or Dreyer's Catalogues, and there is little doubt a systematic search would add greatly to the number already known.

Colonel Cooper's Observatory, Markree.

Double stars within 25° of the pole have been observed at this Observatory, and, besides, a number of difficult and important binary stars have been occasionally examined. At the latter end of the year a number of sketches of planets were secured, and drawings of a few nebulæ have been commenced.

Mr. Edward Crossley's Observatory, Bermerside, Halifax.

There has been very little change in the work of this Observatory during the past year. As heretofore, the measurement of double stars has occupied most of the small number of nights when the sky was clear. More attention than usual has been paid to the delineation of the markings on *Jupiter's* disk, and to the phenomena of *Jupiter's* and *Saturn's* satellites. The list of satellite observations will shortly be submitted to the Society for publication. The Transit Instrument and the Equatoreal are in good working order.

Mr. Huggins's Observatory, Upper Tulse Hill.

Up to the present time photographs have been obtained of the spectra of the stars *Sirius*, *Vega*, *Rigel*, *α Cygni*, *α Virginis*, *η Ursæ Majoris*, *α Aquilæ*, *Arcturus*, *β Pegasi*, *Betelgeux*, *Capella*, *α Herculis*, and *α Pegasi*.

The spectrum apparatus consists of one prism of Iceland spar and lenses of quartz. A slit is employed $\frac{1}{350}$ of an inch in length. The length of spectrum taken with this apparatus is about half an inch from G to O in the ultra-violet. The definition is so good that in photographs of the solar spectrum at least 7 lines can be counted between H and K. The apparatus is adapted to a Cassegrain Reflector with a metallic speculum of 18 inches diameter. The small mirror was removed and the slit of the spectrum apparatus placed at the principal focus of the speculum. A very successful method was adopted by which the image of a star could be brought exactly upon the slit and retained there during the whole time of exposure, sometimes for more than one hour, by a system of continuous supervision and instant control by hand when necessary. The slit is provided with two shutters. By means of these a second known spectrum may be taken upon the plate for comparison.

Various photographic methods were tried, but the great sensitiveness which may be given to gelatine plates, together with the special advantages of dry plates for long exposures, led finally to the exclusive adoption of this method.

The photographs were examined and the lines measured by means of a micrometer attached to a microscope of low power. These measures were reduced to wave-lengths by the help of solar and terrestrial spectra, use being made of M. Cornu's map of the ultra-violet part of the spectrum, and of M. Mascart's determinations of the wave-lengths of cadmium.

The spectra of *Sirius*, *Vega*, *α Cygni*, *α Virginis*, *η Ursæ Majoris* *α Aquilæ*, and *Arcturus* have been laid down in a map on the scale of M. Cornu's map of the ultra-violet part of the solar spectrum.

The stellar spectra extend from about G to O. Six of these spectra belong to stars of the white class. In 1864 Mr. Huggins pointed out the features in common in the visible spectra of these stars.

The photographs present a remarkable typical spectrum, consisting of twelve strong lines. The least refrangible of these is coincident with the hydrogen line (γ) near G; the second with "*h*," also a line of hydrogen; the third with H. K, if present, is thin and inconspicuous.

The lines H and K are coincident with lines in the calcium spectrum, and are usually attributed to the vapour of this substance. There is another pair of strong lines in the calcium spectrum, which on M. Cornu's map have the wave-lengths

3736·5 and 3705·5. There are no strong lines in these stars coincident with these lines.

The twelve strong lines, together with the two other lines of hydrogen, C and F, in the visible spectrum, form a group in which the remarkable arrangement suggests that all these lines belong to one substance. Four at least, and probably a fifth also, belong to hydrogen.

In the photographs of *Vega* and *Sirius* the continuous spectrum extends far into the ultra-violet, beyond S; but in these stars no other lines are present beyond the last line of the typical group which occurs at λ 3699.

For the sake of convenience of reference, these lines have been distinguished by the letters of the Greek alphabet in the order of refrangibility, beginning with the first line beyond K of the solar spectrum.

The wave-lengths of these lines are

1	(Hydrogen near G)	4340	7	δ	3767·5
2	*h*	4101	8	ε	3745
3	H	3968	9	ζ	3730
4	α	3887·5	10	η	3717·5
5	β	3834	11	θ	3707·5
6	γ	3795	12	ι	3699

In all the stars of the white group the line K is absent or thin compared with its condition in the solar spectrum.

In the spectrum of *Arcturus*, which belongs to the solar type, this line exceeds in breadth its condition in the solar spectrum.

The white stars may be arranged in a series, in which the line K passes through different stages of thickness, at the same time that typical lines become narrower and more defined and other finer lines present themselves in increasing numbers.

Arcturus appears to present a spectrum on the other side of that of the Sun in the order of changes from the white star group.

The spectra of the planets *Venus*, *Mars*, and *Jupiter* were taken on the plan suggested by the author in 1864, in which a daylight spectrum is observed and photographed together with that of the planet. These show no sensible planetary modification in this region of the spectrum.

Numerous spectra of small areas of the lunar surface have been taken under different conditions of illumination. They are negative as to the existence of a lunar atmosphere.

Mr. Knott's Observatory, Cuckfield, Sussex.

The year has not been a very favourable one for Observatory work. A few measures of double stars have been taken with the $7\frac{1}{3}$-inch equatoreal and filar micrometer. Of these, two sets of

measures of γ^2 *Andromedæ* give P = 98°·9 for the epoch 1879-81, a result which is in fair agreement with other recent measures' and is confirmatory of the view that the angle of position is slowly but decidedly decreasing.

Observations have also been made of a small number of variable stars. Among these may be mentioned Mr. Hind's U *Geminorum*, a maximum of which was observed on October 24 ±. From the appearance which it presents in the telescope, and from the irregularity of its period (which has a range, according to Dr. Schönfeld, of from 70 to 150 days), this star would seem to belong rather to the class of so-called "new stars" than to the ordinary variables.

The elliptical red spot on *Jupiter* was observed on several occasions. On December 6, six measures were taken of the length of the spot, when near the centre of the disk, the mean result being 13″. At 7h. 15m. G.M.T. on the same evening the *following* extremity of the spot was observed to be on the central meridian of the disk of the planet.

Lord Lindsay's Observatory, Dun Echt, Aberdeen.

This report is for the last two years. In 1878 the transit of *Mercury* was observed, in accordance with a plan detailed in a circular which was distributed shortly before the transit. In addition to the usual contact and diameter determinations, the projection of the planet on the chromosphere was spectroscopically observed by Lord Lindsay. Accounts of these observations, as well as others of the region near the supposed new lunar crater *Hyginus* N., and of meteors on November 27, have been published in the *Monthly Notices*. From the beginning of the year daily readings of the usual meteorological instruments have been made to supplement those of a King's barograph and a standard anemograph.

In 1879 the spectrum of Brorsen's comet was measured five times, and Palisa's comet was observed with the spectroscope on two occasions, and for place on thirteen nights. From the first three observations provisional elements and an ephemeris (published in the *Astronomische Nachrichten*) were deduced. During the latter part of its visibility, when it was so faint as probably to be a difficult object in small telescopes, Swift's comet was compared with neighbouring stars on four nights with the 15·06-in. Refractor. In the autumn a plan was devised for the more rapid and complete distribution of urgent astronomical news amongst British observers by means of a circular posted to all applicants. Two notices have been already distributed, viz. of the Rev. T. W. Webb's minute planetary nebula (the exact nature of which was decisively shown at Dun Echt), and of a hitherto unobserved star discovered in *Canis Minor* by Mr.

Baxendell. Co-operation has been promised from many sides, and a similar scheme has been started in France.

After a revision of the large Refractor, and more especially the removal of every trace of grease from the surfaces of the objective, the outer satellite of *Mars* was readily seen, and measures of its relative place taken on four occasions.

The neighbourhood of Schmidt's *Nova Cygni* was repeatedly scrutinised, and the list of stars within a radius of $7\frac{1}{2}'$ augmented to 97. The reductions of the measures, except to epoch, are all finished. Special attention has been given to the magnitudes.

The Transit-Circle has been used for time determinations, and latterly for fixing the places of a small cycle of occultation and comparison stars. The faintness of these led to a great improvement in the illumination of the wires in a dark field. The four prisms in the cube which reflect light down to the eye-end are so far from the centre-line of the axis as to be partly out of the range of the direct rays from the illuminating lamp. By inserting a group of four prisms of small angle in the axis, so that the rays from each of them cross the centre-line on their way to the prisms in the cube, this difficulty is completely overcome. The rays, too, are kept practically parallel, and so fall only on the internal prisms. The illuminating power thus gained is very great, but is to a considerable extent negatived owing to the light falling at an angle of 45° to the sets of wires, although nearly in the same plane. The full intensity of the illumination is manifested by the brightness of dust particles which happen to be normal to the rays. The systematic division errors of the circle generally used have been determined for every five degrees. The application of these corrections will complete the reduction of the observations of *Mars* and comparison stars made in 1877. The periodic errors of the declination, collimation, and microscope screws have been also determined, as well as the values of the first two.

The Foucault Siderostat has been fitted with slow-motion rods, accessible from any part of a room 68 ft. in length, and the opening through which the rays enter arranged to receive any of the telescope or photographic lenses. This room can be darkened by a single shutter. The electrical control of the chronograph and refractor driving clock (see *Monthly Notices*, vol. xxxiv., p. 35) has been much simplified without impairing its accuracy. The essential parts are reduced to a single commutator wheel, one ordinary Siemens' relay, and a single brake. To avoid passing a strong current through the sidereal clock, an extra relay is introduced.

On December 18, 1879, it was noticed that the last rays of the Sun descending behind a hill five miles off gave rise to a phenomenon closely akin to the "shadow bands" seen in some solar eclipses. A detailed account of the phenomenon was published in *Nature*.

Investigations and reductions connected with the transit of

Venus still absorb the greater part of the Observatory's working power. Twelve of the best photographs have been remeasured, each on two days. These measures, as well as former ones made by Mr. Gill, have been reduced to the neighbouring lines on the fiducial plate, and show no marked personality in the fixation of the limbs of the Sun or planet, nor does the probable error of a complete measure appear to be so large as $\pm 0''.3$. The base bars and auxiliary iron rod with which the distance of the photographic objective from the camera was ascertained have been compared with a copy of the *Mètre du Conservatoire* at temperatures of 55° and 90°. This work involved testing 20 thermometers and finding the lengths of two auxiliary bars for connecting *à trait* and *à bout* measures, as well as an examination of the periodic and other errors of the Fromont dividing engine.

The double-image micrometer has been subjected to a close examination. The periodic errors of both screws were determined for three parts, and observations made for defining the variation of the scale-value with increasing distances have been made by means of artificial stars. The coefficient of expansion of the bar in which these are formed, as well as their intervals and distances from the telescope, have been found. Many separate portions of the whole work have been finally prepared for the press.

The Earl of Rosse's Observatory, Birr Castle.

During the year Parts I. and II. have been published of the Catalogue of Nebulæ and Clusters observed with the 6-ft. and 3-ft. Reflectors from the year 1848 up to about the year 1878. These include 0^h to 14^h R.A. Part III., which completes the work, is in the printer's hands, and will probably be issued in the course of the next few months.

The planet *Mars* was observed several times during the late opposition; one satellite was seen, but no measures of its position were obtained.

A few photographs of the Moon on ready prepared gelatine plates were taken, but with only average results.

Colonel Tomline's Observatory, Orwell Park, near Ipswich.

The work of this Observatory during the past year has been almost entirely confined to the observation of comets, which is held to be the most useful sphere of work to which its appliances can be devoted. An excellent series of observations of Brorsen's Comet has been secured, and the reductions are being now completed; they will be sent to the editor of the *Astronomische Nachrichten* for publication without delay. The observations of Tempel's Comet were meagre and unsatisfactory, owing to its low altitude

and the presence of haze near the horizon at that season of the year. Later on the Comets of Swift, Hartwig, and Palisa have been fairly well observed, but it is to be regretted that the series of the two latter commence much later than might have been the case if intelligence of their discovery had reached the Observatory at an earlier date. These observations will be published as soon as the reductions are effected.

The only other work that has engaged the observer is the determination of the geographical coordinates of the Observatory, which, after some difficulty, has now been completed. It is intended, however, to supplement these results by observation of a certain number of occultations during the current year.

Royal Observatory, Cape of Good Hope.

At the end of 1878 Mr. E. J. Stone accepted the post of Radcliffe Observer at Oxford, and in consequence resigned his position as Her Majesty's Astronomer at the Cape of Good Hope. Before quitting the scenes of his labours for the past nine years he completed the work which led him to the southern hemisphere. This work was the construction of a Catalogue of all stars down to the seventh magnitude between N.P.D. 120° and N.P.D. 180°, and all Lacaille's stars beyond these limits of N.P.D. The whole Catalogue contains 12,400 stars, almost all of which have been observed three times. The Lords Commissioners of the Admiralty have arranged for the work to be printed in England under the superintendence of Mr. Stone, as also the annual volumes for the years 1877–78 and the first half of 1879.

Besides the construction of this Catalogue, Mr. Stone completed the reduction and published the annual volumes of observations from 1856–60, and formed the first Cape Catalogue (epoch 1860) from the material contained in these volumes. He also revised and published the Catalogue for 1840 from observations in 1834–40; the printing of this volume was completed before Mr. Stone's departure for England.

Mr. Stone left for England at the end of May 1879, and was succeeded in his post by Mr. David Gill, who reached the Cape on the day preceding Mr. Stone's departure. Among the old work of the Observatory still remaining for publication must now be mentioned the Catalogue for 1850, containing all B.A.C. stars having south declination. This Catalogue was found by Mr. Gill in a partially reduced state, and it has been pushed forward to completion as vigorously as possible. Nearly the whole of the computations are now finished, but a very heavy labour in examination still remains, because much of the early part of the work, such as reduction to the middle wire and the application of the instrumental corrections, previously assumed to be correct, appears to require careful re-examination. This work

has been much delayed by the illness of Mr. Pett, third Assistant, who was before exclusively employed in the work. His illness has necessitated a voyage to England. The Catalogue, however, will be completed as soon as possible consistently with the reduction of current work.

Besides this Catalogue, there is a valuable series of observations of occultations of stars by the Moon, made by Sir Thomas Maclear, extending from 1834 to 1870. In general, the errors of the observing chronometers have not even been computed, though there are records of careful comparisons with the standard clock before and after each observation. Some progress has been made in the reduction of these observations, but it is not intended to publish them till the determination of a telegraphic longitude of the Cape has given them their full value.

The completion of the submarine cable connecting Aden with D'Urban, and a system of land lines from D'Urban to Port Elizabeth, and from Port Elizabeth to the Royal Observatory, Cape of Good Hope, offer the means of determining the absolute longitude at an early date, because Aden has been already connected with Greenwich by two closely accordant and independent operations, viz:

1. Lord Lindsay's Mauritius Expedition in conjunction with the German Transit of *Venus* Expedition, when Aden-Suez and Suez-Alexandria were connected by Dr. Löw and Mr. Gill, and Alexandria-Malta and Malta-Berlin by Dr. Auwers, Dr. Löw, and Mr. Gill.
2. Sir George Airy's connection of Suez and Alexandria with Greenwich by the British Transit of *Venus* party in Egypt, and the after-determination of Suez-Aden under General Walker by officers of the G.T. Survey of India.

The necessary preliminary inquiries have been instituted as to instruments and telegraphic possibilities; when these have been completed, plans and estimates for the operation will be submitted to the authorities.

The important work completed by Mr. Stone has led Mr. Gill to consider very fully the proper objects to which the use of the Transit-Circle should be devoted in future. To continue the same class of observations as those of Mr. Stone would be useless; indeed, for the particular class of observation which he undertook, Mr. Stone has completed the work of the southern heavens for the next fifty years.

Two separate lines of meridian work seemed peculiarly open for solution:—

1. The construction of a limited Fundamental Catalogue of the Southern Heavens, including observations of the Sun and observations for latitude and refraction.
2. The observations of successive zones of stars down to the 9th magnitude from N.P.D. 120° on the plan of the *Astronomische Gesellschaft*.

After full consideration, Mr. Gill adopted the former pro-

gramme, because it not only appeared the more pressing and necessary in the present state of Astronomy, but also because Dr. Gould is known to be occupied with the latter work at Cordoba.

As part of the fundamental work, the observation of 250 stars (to be used by Dr. Schönfeld as fundamental stars in his Durchmusterung from N.P.D. 90° to 120°) has been undertaken.

For this work it was found that considerable changes were necessary in some details of the Transit-Circle.

The circle microscopes were defective in some points of construction, and the screws seemed to be worn, as different zenith points were found by the use of different parts of the screws. No means existed for determining the errors of the screws. The microscopes were accordingly sent to Mr. Simms to have new screws made and to be altered in some other respects, and an apparatus was contrived by Mr. Gill for determining the screw errors. The latter apparatus is now in course of construction by Mr. Simms. The improved microscopes, with their new screws, and adapters fitted for the screw-error apparatus, have been recently received, and are now mounted and adjusted. The arrangement of the webs has been altered from the now obsolete form of cross wires to that of parallel wires just embracing the division, and this, with a thorough revision of the focussing and illuminating arrangements, has very greatly increased the precision of the circle readings.

A re-examination of the division errors of the circle has been undertaken and completed as far as each 20th degree. Three different observers have taken part in the work, and the error of each division has been arrived at by three independent processes by each observer. The results by all methods and by all observers are in admirable agreement, but in some divisions there is considerable discordance from the previous determinations of division error, in which cross wires were employed. The determinations of the errors of the 5° spaces is now being carried out.

The new eye-end, which was received in the early part of 1879, but which had not been employed by Mr. Stone, was not found to be at all satisfactory; and particularly its drawtube did not fit, having been made to measure, and Mr. Simms having had no opportunity of trying it *in situ*. The old eye-end was accordingly returned to Mr. Simms to be provided with new micrometer screws and otherwise repaired.

Its arrival, now rather unduly delayed, is anxiously expected. An arrangement has been contrived by Mr. Gill for determining the astronomical flexure of the Transit-Circle at different altitudes, and plans and estimates have been prepared for the erection of an accessible meridian mark in the focus of a lens of 300 feet focal length. It is hoped that these proposals will meet with the approval of the authorities.

The deficiencies of the Transit-Circle eye-end have prevented much being done in the way of fundamental work, but considerable progress has been made with the Right Ascensions of Professor Schönfeld's stars.

A very extended series of observations on personal equation has been carried out. The results are of great interest, and will be shortly published.

α and β *Centauri* have been observed at every culmination when weather permitted. On 71 days observations of both stars have been already secured, and it is intended to continue the observation of both stars regularly in R.A. and N.P.D., in order, not only to test independently whether the results of Henderson and Maclear for the parallax of α *Centauri* will be confirmed, but also whether (in conjunction with the long series of similar observations of these stars to be found in the records of the Observatory, both published and unpublished) it may not be possible to determine the motion of the centre of gravity of the system α_1 and α_2 *Centauri*, and thus, in combination with the existing and future measures of position angle and distance of the stars, determine their relative masses.

With regard to extra-meridian observations. The extent of meridian work undertaken and carried out by Mr. Stone rendered it impossible for him to attempt extra-meridian work; and accordingly, though a new mounting had been provided for the Equatoreal, the instrument had never been brought into working order. Much time and labour were required to get the instrument into good adjustment, and considerable alterations had to be made before the whole was completed. As no skilled workmen can be obtained at the Cape, the work consumed a good deal of Mr. Gill's time. The illumination of the field is still very bad; but arrangements have been planned, and are now being executed by Mr. Simms, which, it is believed, will be satisfactory in this respect. The object-glass, though by Merz, is not of the highest quality, and the aperture (6·9 inches) is much too small for many purposes of modern research. The telescope may be usefully enough employed for observations of occultations of stars by the Moon, of the phenomena of *Jupiter's* satellites, and, when the illumination is arranged, for measures of not too difficult double stars; but for the more refined investigations of parallax and for stellar spectroscopic work the instrument is not adequate.

At the request of Professor Newcomb, the regular observation of all occultations visible at the Cape of stars in the *Nautical Almanac* occultation list has been undertaken. The Lords Commissioners of the Admiralty have provided for the prediction of these occultations, from the 1st January 1880, for the Royal Observatory at the Cape in the same manner as for the Royal Observatory, Greenwich. The regular observation of the eclipses of *Jupiter's* satellites has been commenced, and will form part of the work of the Equatoreal.

A determination of the parallax of α *Centauri* by differential measures of distances, or of declination from neighbouring stars, was looked upon by Mr. Gill as one of the most immediately interesting and important problems presented to an astronomer in

the southern hemisphere. There are, unfortunately, no stars suitably situated near *α Centauri* which are at the same time bright enough for measurement with so small an aperture as 6·9 inches, though for an Equatoreal of large aperture there are stars suitable for both methods. Before leaving England Mr. Gill received an unexpected and generous offer in the shape of a loan of Mr. Newall's 25-inch Equatoreal and its Observatory for use at the Cape during a period of seven years, on the simple conditions that at the end of the period in question the instrument should be returned to Mr. Newall, if required, free of expense. With similar generosity, Mr. James Nasmyth offered to contribute £1,000, and Dr. Siemens £250, towards the cost of transport and erection. The matter only came before Mr. Gill on the eve of his departure from England, and Messrs. Spottiswoode, Huggins, Nasmyth, De La Rue, and Siemens, together with Lord Lindsay, kindly agreed to form a committee to make the necessary inquiries and decide what should be done under the circumstances. It was found that the total cost of dismounting and altering the instrument, together with packing and transport of the observatory and instrument, erection at the Cape, and providing for re-transport and re-erection at the end of seven years would amount to about £3,000. The committee, seeing that a new Equatoreal equal to the requirements of modern times was in any case necessary, thought it a pity that so much money should be expended on a borrowed telescope, and accordingly it was not thought desirable to accept Mr. Newall's generous offer. They also thought that the new Equatoreal should be of not less than 20 inches aperture, and Mr. Nasmyth intimated his desire to subscribe £1,000 towards the cost of such an instrument whenever its construction should be decided upon. Preliminary correspondence has been opened on the subject, but no steps have as yet been officially taken in the matter. It is a matter of regret that some time must elapse before the Observatory can be provided with a suitable Equatoreal.

Mr. Gill has purchased from Lord Lindsay the Heliometer used in the *Juno* and *Mars* observations, and a new equatoreal mounting of great rigidity is now being made for it to Mr. Gill's order by Mr. Howard Grubb, of Dublin. The Lords Commissioners of the Admiralty have granted free transport of the instrument; an observatory is prepared for its reception, and observations will probably be commenced before the middle of the present year. The instrument will be devoted in the first place to the observation of *ζ Indi* and one or two other stars having large proper motion, for determination of their parallax.

Melbourne Observatory.

The meridian work with the Transit-Circle at this Observatory during the past year has been principally confined to completing the series of observations of all stars observed for the next Ten-year Catalogue.

The reductions of the observations obtained in the zones 150° to 160° S.P.D. have been considerably advanced, and out of the 48,672 observations recorded 36,000 have been reduced in both R.A. and P.D.

The Great Telescope has been kept unremittingly at work on the revision of Sir John Herschel's southern nebulæ. During the year 60 of the smaller nebulæ and clusters contained in the Catalogue have been observed, compared, and drawn.

A large part of the drawings of the nebulæ made with this telescope, from its erection in 1868 up till the middle of 1878, are now being printed, some of which will be issued in parts, with notes, in a few weeks.

Among the occasional work of the year may be noted the conjunction of *Mars* and *Saturn* on July 1 last, which was satisfactorily observed with both the large Reflector and 8-inch Refractor; the occultation of 64 *Aquarii* by *Jupiter* on September 14; and a search for *Mars'* satellite "Deimos" in October and November.

With regard to the latter observations, it will be remembered that *Mars'* satellites could not be found with the Great Telescope during the opposition of 1877. At the present opposition, however, the outer satellite was observed on several occasions in November, namely, the 4th, 6th, 13th, 15th, and 20th; but, except in one instance, it was always too faint to obtain any satisfactory measures. In the instance referred to, November 13, the position was approximately measured as 54° 15′ at 10h. 40m. Melbourne mean time.

The publications issued from the Observatory during the past year are volume 5 of *Results of Astronomical Observations*, which includes the work of the years 1871-2-3-4-5, and the usual *Monthly Records of Meteorology and Terrestrial Magnetism.*

Notes on some points connected with the Progress of Astronomy during the past year.

Discovery of Minor Planets.

A considerable addition to the list of minor planets has been made since the date of the last Report, owing principally to the observing activity of M. Palisa, of Pola, and Dr. C. H. F. Peters, of the Litchfield Observatory, Clinton, New York, to whom the discovery of nineteen during the year is due. The remaining two were discovered at Marseilles by M. Coggia and M. Borrelly.

No.	Name of Planet.	Date of Discovery.	Name of Discoverer.	Mean Distance. (Earth = 1).
		1879		
(192)	Nausicaa	February 17	Palisa	2·401
(193)	Ambrosia	February 28	Coggia	2·626
(194)	Procne	March 21	Peters	2·653
(195)	Eurycleia	April 22	Palisa	2·874
(196)	Philomela	May 17	Peters	3·082
(197)	Arete	May 21	Palisa	2·753
(198)	Ampella	June 13	Borrelly	2·479
(199)	Byblis	July 9	Peters	3·206
(200)	Dynamene	July 27	Peters	2·741
(201)	Penelope	August 7	Palisa	2·676
(202)	Chryseis	September 11	Peters	3·076
(203)	Pompeia	September 25	Peters	2·742
(204)	Callisto	October 8	Palisa	2·673
(205)		October 13	Palisa	2·689
(206)	Hersilia	October 13	Peters	
(207)		October 17	Palisa	2·283
(208)		October 21	Palisa	2·872
(209)	Dido	October 22	Peters	3·168
(210)		November 12	Palisa	2·754
(211)		December 10	Palisa	3·048
		1880		
(212)		February 6	Palisa	

The relative positions of the new minor planets in the group of asteroids may be inferred by a reference to the last column in the table, remembering that the mean distance of *Flora*, the nearest minor planet to the Sun, is 2·201, and that of *Hilda*, the farthest from the Sun, is 3·950.

The following planets, discovered in preceding years, have only been recently named:—

No. (174)	Phœdra.	No. (182)	Elsbeth.
„ (175)	Andromache.	„ (183)	Istria.
„ (179)	Clytemnestra.	„ (187)	Lamberta.

The Comets of 1879.

Five comets have been under observation during the past year, including Brorsen's comet of short period and Tempel's periodical comet of 1867. The remaining three are believed to be new comets.

1. Brorsen's periodical comet was first detected by M. Tempel, at the Arcetri Observatory, Florence, on January 14, 1879, when quite close to the horizon. The comet rapidly increased in brightness after it was first seen, being six times as bright on March 15, and brighter still in April. It passed its perihelion on March 30. A valuable ephemeris of Brorsen's comet was computed by Professor Schulze in anticipation of its appearance.

2. Tempel's first periodical comet (Comet II, 1867) was detected on April 24, at the Arcetri Observatory, Florence, where a long series of observations was made by M. Tempel during the two following months. The comet, when first noticed, was extremely faint and small. Viewed with Mr. Common's 18-inch Reflector on May 25, its nucleus appeared to be considerably out of the centre. On June 10 the comet was round and diffused, about $30''$ in diameter. Observations of Tempel's comet have been made at several Observatories both in Europe and America. At Rio Janeiro it was observed by M. Cruls, of the Imperial Observatory, to whom it also appeared as a faint round nebulosity, with a slight condensation in the centre. According to the elements calculated by Dr. Raoul Gautier, this comet passed its perihelion on May 7.

3. A telescopic comet was discovered by Mr. Lewis Swift, at Rochester, N.Y., on June 15. The nucleus was of the ninth magnitude, and the comet about $3'$ in diameter. Elements of this comet were computed by Dr. Küstner, under Professor Winnecke's superintendence, which appeared to represent the observations very closely. The perihelion passage, according to these elements, occurred on April 27. This comet was observed through telescopes with small aperture until the end of July.

4. A comet was discovered by M. Palisa, at Pola, on August 21. It appeared with a round bright disk, and was easily visible in small telescopes. According to elements calculated by Mr. S. C. Chandler, its perihelion passage took place on October 4.

5. The fifth comet was discovered by Dr. Hartwig, at Strasburg, on August 24. It was a very faint object, and, owing to the unfavourable weather, was not much observed in England.

Mr. G. H. Darwin's Researches on the History of the Solar System.

In the Annual Report for last year a short notice was given of Mr. Darwin's investigations on the influence of geological changes on the rotation of the Earth. Mr. Darwin was thus led to examine the consequences of an absence of perfect rigidity in the Earth's mass, and the results of his researches have been communicated to the Royal Society in four Memoirs, entitled "On the bodily tides of viscous and semi-elastic spheroids, and on the ocean tides upon a yielding nucleus," "On the precession of a viscous spheroid, and on the remote history of the Earth," "Problems connected with the tides of a viscous spheroid" (*Phil. Trans.*, 1879), and "The determination of the secular effects of tidal friction by a graphical method" (*Proc. Roy. Soc.*, 1879).

The first of these Memoirs relates chiefly to the forced oscillations of a viscous sphere, or of a sphere whose elasticity breaks down under continued stress. Supposing the forced oscillations to be produced by the attraction of a satellite revolving about the sphere or planet, the author investigates the law which governs the retardation and height of the tide, and also the acceleration and reduction in height of the tide in an ocean superimposed upon the viscous nucleus. Numerical calculations show that the bodily tides are at present very small in amount, and the author infers that the actual effective rigidity of the Earth's mass must be very large as compared with that of known viscous substances. The method employed is based upon a somewhat similar investigation by Sir William Thomson in regard to an elastic sphere.

A consequence of the retardation of the tides in the viscous planet is found to be that the attraction of the satellite upon the planet is not equilibrating, and that the rotation of the planet is therefore modified. The author is thus led to the investigation contained in the second paper, which has for its object the examination of the effect of frictional tides both upon the planet in which they are raised and upon the satellite which raises them. It appears from the investigation, which is carried out by means of analytical developments of considerable complexity, that the obliquity of the planet's equator will increase or decrease according to conditions set forth in the paper; and that, if the planet and satellite revolve in the same direction, and the satellite revolves slower than the planet rotates, the angular velocity of the planet's rotation will decrease and the mean distance of the satellite increase. By means of the equations which give the rate of retardation of the planet's rotation and of the

satellite's mean motion, a relation is found between the heights and retardations of the several tides existing in the planet and the acceleration of the satellite's motion which would appear to take place to an observer whose measure of time was derived from the planet's rotation. The author then applies these considerations to the hypothesis that the hitherto unexplained part of the secular acceleration of the Moon's mean motion is due to the action of bodily tides in the Earth, from which it appears that the tides in the Earth must either be of very small amount or must be subject to very small retardation. This would seem to confirm the opinion that the Earth's mass at the present time possesses great effective rigidity.

In this paper the investigation was intended to apply especially to the case of the Earth, Moon, and Sun; but the introduction of the solar attraction, which was found to be of considerable importance, rendered the differential equations so complex that the author has substituted for the complete analytical solution a retrospective arithmetical integration by the method of quadratures. The integration is carried back in detail until the day is reduced to six hours and the sidereal month to twelve hours and the obliquity of the Ecliptic to 14°. In this investigation the inclination of the lunar orbit to the Ecliptic is neglected, and it is stated that the simultaneous changes in the plane of the lunar orbit would be such as to modify the result in the case of the obliquity. (In a subsequent paper, however, communicated to the Royal Society in December 1879, Mr. Darwin has taken account of the inclination and eccentricity of the lunar orbit.) The detailed integration is not carried further back, but, by means of the equation of conservation of moment of momentum, the author is enabled to determine approximately the initial configuration from which, according to the theory, the Moon and Earth had their origin. Neglecting the obliquity of the Equator, the equation of conservation involves two variables, viz. the rotation of the planet and the mean motion of the satellite; and if one of these be put equal to the other, the equation becomes a biquadratic which has two real roots.

The physical interpretation of these two roots is that a system of a planet and satellite may be started revolving, as the parts of a rigid body, in two different ways, and that one of these configurations involves a maximum of energy and the other a minimum.* As the system is by hypothesis subject to friction, it must necessarily degrade from the position of maximum energy to that of minimum. In the detailed integration already referred to the energy of the system continually increases as we go further back, and therefore the earliest state to which it would admit of being traced is that of maximum energy. This state of maximum energy in the case of the Earth and Moon is one in which the

* This subject is considered more especially in the paper above referred to in the *Proceedings of the Royal Society*.

Moon is very nearly in contact with the Earth. The author also shows that an inferior limit to the time requisite for the degradation of the system from the configuration of maximum energy to its present condition is 54,000,000 years. The proximity of the Moon to the Earth and the rapid revolution of the system in this initial state led the author to suggest that the Moon had its origin in the rupture of a primeval planet, partially fluid and partially solid, and that the Moon has attained its present distance from the Earth by means of the reaction of the tides in the lapse of ages. Reference is made to the applicability of similar views to the cases of the other planets, but a complete discussion of the matter is postponed for a future occasion. The paper also contains discussions of the modification of the precession of a spheroid in which tides are being raised, the influence of solar tidal reaction on the length of the year, the influence of tides of the second order, the influence of tides produced by an annular satellite, and the general case of the orbital revolution of two bodies, each of which raises tides in the other.

The third paper contains investigations upon certain problems connected with the tides of a viscous spheroid. If the rotation of a viscous spheroid be retarded by the attraction of a satellite upon the lagging tide raised by that satellite, it is found that the distribution of the tidal frictional couple in various latitudes is not such that the rotation of the planet can be retarded exactly as though it were a rigid body. This gives rise to a screwing motion of the whole mass of the planet, and produces a slow motion from west to east of the polar regions relatively to the Equator. This distortion however must, at least in the later stages of the Earth's history, have been exceedingly small in amount, and cannot be regarded as affording any explanation of the observed crumpling of strata. Assuming the evolution of the Earth and Moon already explained, this screwing action may once have had some importance, and it is suggested as at least possible that the northerly and southerly trend of our great continents may be due to the effects of this cause in the remote past.

It has been already mentioned that in consequence of the friction of the tides the energy of the system degrades: this is only true of the kinetic and potential energy of the system. The principle of the conservation of energy necessitates that the lost energy should reappear in the form of heat. The second portion this paper contains an investigation of the distribution of heat generated by friction within a tidally distorted viscous spheroid. It appears that by far the larger part of the heat is generated in the central regions.

If the Earth and Moon have passed through the supposed history, then it is shown that the whole heat generated in the Earth from first to last would give a supply of heat at the present rate of loss by cooling for 3,600 million years. The author first believed that this prodigious amount of heat might be an im-

portant cause of the increase of temperature in borings and mines, and thus that Sir William Thomson's investigation of the secular cooling of the Earth might require to be largely modified; but an investigation specially undertaken to decide this point shows that the present increase of underground temperature due to this cause could hardly exceed 1° Fahr. for every 2,600 feet, whereas we know that the actual amount is 1° Fahr. in 50 feet.

The third question relates to the part played by inertia in the forced oscillations of viscous fluid and elastic spheres. In the theory of tides employed by him in his investigations up to this point the inertia is neglected, and the author here shows that the introduction of inertia will not sensibly affect the results.

Mr. Darwin has also communicated to the Royal Society a fifth Memoir, of which the abstract alone has as yet appeared. In this Memoir the inclination and eccentricity of the orbit of the tide-raising satellite are the subjects principally considered, and the author is led to some remarkable results relating to the history of the solar system.

Oppolzer's Treatise on the Calculation of the Orbits of Comets and Planets.

In the course of the year Professor Oppolzer, of Vienna, has issued the second volume of his *Lehrbuch zur Bahnbestimmung der Kometen und Planeten*, and although it is not usual in this Report to notice the publication of astronomical treatises, the contents of the present work seem likely to be so useful to the mathematical astronomer, and to meet a want that so many mathematicians must have felt, that it seems desirable to direct attention to it.

The first volume was issued in 1870, and contained 353 large octavo pages; the second, which has just appeared, contains 635 pages, of which 120 are devoted to tables, some of which have been calculated especially for the work.

The first chapter, on numerical differentiation and integration, relates to the general application of mathematics to numerical work. The second chapter, which occupies more than 200 pages, is devoted to the explanation of the method of calculation of special perturbations. As an example, the perturbations of *Erato* (62), due to *Jupiter* and *Saturn*, are worked out in full numerical detail by Encke's method, and also by the Hansen-Tietjen method. The third chapter contains an elaborate account of the practical application of the method of least squares to the treatment of astronomical observations; and the fourth to the deduction of the elements from a great number of observations. The account of the method of least squares, though of course somewhat resembling that given by Encke in the *Berliner Jahrbuch*, and reproduced by Chauvenet in his

Astronomy, is much more full and detailed as regards the actual numerical formation and solution of the equations. The theoretical basis on which the method rests is, however, as was to be expected in a practical treatise, not specially considered; but there is no other work in which so complete an explanation of the processes is to be found. Lambert's equation is also treated at length, and there is added a table of a function which occurs in connection with it, calculated by Herr F. K. Ginzel. Some portion of the scope of the work is covered by Mr. T. C. Watson's *Theoretical Astronomy*; but as regards fulness of mathematical and numerical detail, Dr. Oppolzer's work is unique.

Such a book is not only useful to the practical astronomer, but is also in the highest degree valuable to the mathematician who desires to know the exact manner in which the dynamical formulæ he is acquainted with are actually applied in practice to the calculation of orbits &c. There is a considerable interval between the analytical formulæ of disturbed elliptic motion and the actual methods in use for practically determining the perturbations of the heavenly bodies; and the present work may be regarded as supplying the connection between the two.

Auwers's "Fundamental-Catalog für die Zonen-Beobachtungen am Nördlichen Himmel."

This Catalogue has been recently published by the *Astronomische Gesellschaft* in furtherance of the work of zone-observations of stars down to the 9th magnitude, which has been in progress for some ten years. The task of compiling the Catalogue has been entrusted to Dr. Auwers, and has been executed by that astronomer in his usual careful and complete manner. The Catalogue contains the places, for the epoch 1875·0, of the 336 Pulkowa fundamental stars, and of certain additional stars, bringing the total number up to 539. The places of these stars may probably be considered to be as accurately determined as is possible in the present state of astronomical science, especially when it is remembered that Dr. Auwers uses the proper motions of the Bradley stars in the Catalogue (which constitute a very large proportion of the entire number) determined from a comparison of his, as yet unpublished, Bradley Catalogue for 1755 with the best modern observations.

Dr. Auwers' places are derived from a combination of the observations made at Pulkowa, Greenwich, and Cambridge, U.S., for the right ascensions; and for the declinations he has used, in addition to these, observations made at Leipzig and at Leiden. The Pulkowa observations made use of are: 1st, the right ascensions and declinations for 1845, the former deduced from observations made during the years 1842–1853, the latter from observations made 1842–49; and, 2ndly, a MS. Catalogue by

Herren Wagner and Nyrén, for the epoch 1871, deduced from the observations 1869–1874. The Greenwich observations used are: 1st, a MS. Catalogue of the Bradley stars observed at Greenwich, 1836–1872, and reduced to 1861; and, 2ndly, the Nine-year Catalogue for 1872, the star-places of which were forwarded to Dr. Auwers by the Astronomer Royal some time before its publication. The Catalogue places mainly depend, as might be expected, on these Pulkowa and Greenwich observations, though exception might, perhaps, be taken to the great weight which has been assigned to the Pulkowa results.

The publication of this Catalogue will doubtless add materially to the already great reputation of its author, and will do much for the efficient progress of the important work which is being carried out under the auspices of the *Astronomische Gesellschaft.*

Uranometry.

Our knowledge of the brightness and distribution of the visible stars, designated by the title Uranometry, has made some highly important advances in the last few years. The valuable series of observations by Mr. Peirce, carried out under the auspices of the Harvard College Observatory, which was noticed in the Council's Report last year, was a distinct advance in the photometry of naked-eye stars. During the past year Professor Pickering has published, in Part I. of vol. xi. of the *Annals of Harvard College Observatory*, a very extensive series of photometric observations of the visible stars, made with photometers of peculiar and original construction on the 15-inch Equatoreal Telescope, during the years 1877–79. With these observations are included a comparison of the relative light of the components of 239 bright double stars. The value and importance of this work will be more fully appreciated when the reduction of the observations, which will be published in Part II. of this volume, is in the hands of Astronomers, when a detailed examination of the whole can be properly and satisfactorily made.

The contributions, however, of the Harvard College Observatory to Uranometry do not stop here, for during the past year Professor Pickering has undertaken the determination of the light of all the stars visible to the naked eye in the latitude of his Observatory. For this purpose a Catalogue of about 4,000 stars has been formed, arranged in the order of R.A. for the epoch 1880·0. It includes all the stars in the *Uranometria Nova* of Argelander, all the stars in the *Atlas Coelestis Novus* of Heis, and in the *Durchmusterung* to the 6th magnitude inclusive, and those in Behrmann's *Atlas des Südlichen gestirnten Himmels* north of 30° S., besides a few stars from other authorities. A novel photometric method is adopted which possesses many important advantages. In his Annual Report

Professor Pickering says: "As most of these stars are inconspicuous objects, much time would be lost in identifying them in the field of a photometer mounted on an ordinary stand. This is avoided by observing them in the meridian as with a transit instrument. The photometer consists of a horizontal telescope pointing to the west and having two objectives. By means of two prisms mounted in front of the telescope, the Pole Star is reflected into one object-glass and the star to be measured into the other. The cones of light are made to coincide by a double-image prism, the extra image being cut off by an eye-stop. The star to be measured is thus seen in the same field with the Pole Star, with the same aperture and magnifying power. Many of the errors to be apprehended in the use of the Zöllner photometer, and other instruments in which the comparison is made with an artificial star, are thus eliminated. To determine the relative transparency of the air at different altitudes, a list of 100 circumpolar stars has been prepared to be observed at both upper and lower culminations." The results of this original method of observation will be looked forward to with peculiar interest.

In 1878 M. Houzeau published, in vol. 1 of the new series of the *Annales de l'Observatoire Royale de Bruxelles*, an interesting "Uranométrie Générale," contained in a Catalogue of the magnitudes and positions of nearly 6,000 stars observed by him with the naked eye in both north and south hemispheres. During a residence of some years at Jamaica, M. Houzeau was able to construct a chart of stars visible to the naked eye, which he plotted down without distinction of magnitude. A rapid re-examination of them during a period of 13 months enabled him to estimate and record their respective magnitudes. The results are contained in four Catalogues, each arranged in order of R.A.

+90°	Decl. to	+45°	885 stars
+45°	„	0°	2031 „
0°	„	−45°	2053 „
−45°	„	−90°	750 „
		Total	5719

The Catalogues give approximate places for 1880, magnitudes, date of observation, and name. The most ancient Catalogues of stars with which we are acquainted expressed brightness in thirds of magnitudes. For instance, Ptolemy designates stars as either 3rd mag., large 3rd mag., and small 3rd mag., corresponding to Argelander's notation of 3 mag. 3–2 mag. and 3–4 mag. This example was continued by the Orientals, and has been imitated in the present day in the Uranometries of Argelander, Heis, and Behrmann. It is unfortunate that M. Houzeau has expressed his results only to half magnitudes, and the value of the work is thereby much impaired. A large number of the

stars are given without name or designation, and consequently their identification is difficult. The No. in the B.A.C. might here have been advantageously inserted. The Catalogues are accompanied by five charts, two of which are devoted to the north and south polar zones to P.D. 45°, and the other three to a cylindrical projection of the equatoreal zone. M. Houzeau has appended some interesting chapters on the Milky Way, and on the distribution of the visible fixed stars, considered: first, with reference to the plane of the Sun's equator; secondly, to the point in the heavens towards which the solar system is moving; thirdly, at right angles to this direction; and fourthly, with respect to the Milky Way. The conclusion arrived at is expressed by the author as follows: 'Les étoiles les plus brillantes et les étoiles les plus faibles sont celles qui se montrent le plus soumises à l'influence de la Voie Lactée; tandis que celles d'un éclat moyen, vers la limite de la visibilité à l'œil nu, en sont les plus affranchies.'

But the work recently published by Dr. Gould, of Cordoba, is perhaps the most important contribution to Uranometry that has appeared since the *Uranometria Nova* of Argelander. The title is "*Uranometria Argentina: Brightness and Position of every Fixed Star down to the Seventh Magnitude within One Hundred Degrees of the South Pole.* By Benjamin Apthorp Gould. With an Atlas. Buenos Ayres. 1879." 4to. pp. 385. It forms vol. i. of "Resultados del Observatorio Nacional Argentino en Córdoba."

In 1870 Dr. Gould proceeded to Cordoba to establish an Argentine National Observatory, and experiencing numerous delays in carrying out the work, he determined to devote the time of himself and his assistants to the formation of a uranometry of the southern hemisphere analogous to that of Argelander in the northern. As he decided to adopt the scale of the *Uranometria Nova*, he devoted considerable time to the determination of standard stars. For this purpose he selected only such stars as are situated within about 5° of that parallel of declination which has the same altitude at Cordoba and at Bonn. Hence his typical magnitudes are contained in a zone between 5° and 15° of north declination. To quote his words: "For each order of magnitude below the second, those stars were carefully selected whose brightness was found best to represent the average of those assigned to the same order by Argelander; and taking this degree of brightness for a point of departure, estimates of magnitude to the nearest tenth of a unit were made for all the stars of his Uranometry within the type-belt, and these estimates were then repeatedly revised in such manner as best to represent the scale of Argelander as a complete system." Four observers were engaged in the work, and only those stars were adopted as standards of magnitude regarding which the four observers all agreed. It was found that it was too difficult to compare the the typical stars with those near the South Pole, and therefore a series of new standards much nearer the Pole were determined

as before. Upon these typical magnitudes all the determinations in the *Uranometria Argentina* depend.

Dr. Gould seems to have been especially favoured in atmosphere, for he says that there is no doubt, in the most favourable nights, stars of 7·0 mag. are easily seen at Cordoba by ordinarily good vision. His aim was to determine the magnitudes of all stars within two or three tenths of a unit below 7·0 mag. To determine a standard for these faint stars, Dr. Gould made experiments by the method of limiting apertures, and finally adopted results which showed that an increase of 0·01 inch in the diameter of the aperture corresponds approximately to an additional 0·1 magnitude for stars of that order of brightness. But his standards of 7·0 mag. were practically determined by continuing downwards the series of differences of 0·1 mag. between 5·0 and 6·0 mag. With regard to the accuracy with which magnitudes can be determined, Dr. Gould makes the rather surprising statement that he has little doubt that "for stars of the seventh order gradations of light corresponding to no more than the *thirtieth* of a unit may be unhesitatingly recognised without more optical aid than a common opera-glass." Observations were made of nearly 1,800 stars for standards, and only those were adopted upon which the accordance of the four observers was absolute; these amounted to 722. He has great confidence in the accuracy of the results, for he says that "There have been instances in which, by common consent, the adopted magnitude for a star has been changed by 0·2 or 0·3, but I am strongly of opinion that in the great majority of such cases the change has been in the star itself rather than in the appreciations of its magnitude."

The Catalogue of 722 Standard Magnitudes is given and compared with the *Durchmusterung*, Lalande, Bessel, *Uranometria Nova*, Heis, and Dr. Gould's own determinations in 1858, at Albany, U.S.; it is followed by many valuable notes.

The important and difficult question of the boundaries of the constellations has received careful attention and modification. The following are the main principles which have guided the author in dealing with the southern constellations:—

1. The constellations of Ptolemy and Hevelius, together with those of Lacaille, are retained.

2. The Latin form is employed for the names.

3. The boundaries are arranged so that the constellations shall include all stars designated by Greek letters by their authors. The boundary lines to be formed, whenever possible, by meridians of right ascension and parallels of declination for the mean equinox of 1875·0. The result of this is necessarily the transference of several stars to other constellations than they belong to in Argelander's *Uranometria Nova*. Appended to these is a careful specification of each constellation and its position in the celestial sphere.

An idea of the extensive work accomplished by Dr. Gould may be formed from the fact, that in three years the magnitudes of

10,650 stars were determined, involving more than 46,000 independent estimates of magnitude.

The *Uranometria Argentina* is contained in a Catalogue of the positions and magnitudes of 7,730 stars, all above 7·1 mag. Approximate places are given for the equinox of 1875·0, the stars being arranged in order of R.A. according to constellations. A somewhat inconvenient method of arranging the constellations has been adopted. "Beginning with *Octans*, which includes the South Pole, they follow the order of the polar distances of their southern limits, proceeding spirally around the celestial sphere in the direction of right ascensions." The result is an anomalous arrangement, which places *Canis Major* next to *Ophiuchus*, *Lepus* next to *Aquarius*, and *Pisces* next to *Leo*. Not the least important part of this splendid volume are the notes to the Catalogue, which occupy over 100 pages, giving details of the colour and variability of stars, with their range of brightness.

The Catalogue is accompanied by an atlas of thirteen charts, together with an index-map. The first is a polar chart, extending to a radius of $32\frac{1}{2}°$ round the South Pole. The six which follow contain the belt between the parallels of $72\frac{1}{2}°$ and $27\frac{1}{2}°$ South Decl., the six next contain the equatoreal belt between $32\frac{1}{2}°$ South and $12\frac{1}{2}°$ North Decl. The charts are constructed on the stereographic projection, corresponding to a sphere of which the radius is one metre. Being reproduced by photolithography, they were drawn upon the scale of a sphere 104 centimetres in radius, to permit of a slight reduction. Stars are represented by circular dots, of which the areas are proportional to the amount of light. Names of stars are omitted, and the lines of R.A. and Decl. being faintly drawn, the result is, perhaps, the most beautiful and perfect representation of the heavens yet published, and is a fitting atlas for so valuable a Uranometry as Dr. Gould has presented to Astronomy. This work concludes with a discussion of the distribution of the stars according to the magnitudes assigned by Gould, Argelander, and Heis; the following being the principal conclusions arrived at by Dr. Gould:—

"1. There is in the sky a girdle of bright stars, the medial line of which differs but little from a circle, inclined to the galactic circle by a little less than 20°.

"2. The grouping of the fixed stars brighter than 4·1 mag. is more symmetric relatively to that medial line than to the galactic circle; and the abundance of bright stars in any region of the sky is greater as its distance therefrom is less.

"3. The known tendency to aggregation of faint stars towards the Milky Way is according to a ratio which increases rapidly as their magnitudes decrease, and the law of which is such that the corresponding aggregation would be scarcely, if at all, perceptible for the bright stars.

"4. These facts, together with others which have been stated, indicate the existence of a small cluster, within which our system is eccentrically situated, but which is itself not far from the middle

plane of the Galaxy. This cluster appears to be of a flattened shape, somewhat bifid, and to consist of somewhat more than 400 stars of magnitudes from the first to the seventh, their average magnitude being about 3·6 or 3·7.

"5. The general distribution of the fixed stars according to magnitude does not appear capable of being well represented by any simple algebraic expression. Yet, by adopting the data of the preceding paragraph and supposing the several magnitudes of the stars in the cluster to follow the Law of Probabilities, we obtain for each class of magnitudes a number which being subtracted from the observed number in the sky leaves a system of distribution which may be represented by the expression $\Sigma_m = ab^m$ within the limits of errors of observation.

"6. The accordance thus obtained holds good for the stars of both hemispheres down to the lowest limits of magnitude for which trustworthy enumerations exist.

"7. The form of the expression $\Sigma_m = ab^m$ is that which corresponds to the hypotheses that in general the stars are distributed at approximately equal distances from one another and are of approximately equal intrinsic brilliancy. It is, however, not requisite for its application that their distribution be equable in all directions, but only that their number be proportional to the volume of the spherical shell within which they are contained.

"8. Each of the authorities (Argelander, Heis, and Gould) and each hemisphere, affords data from which result essentially the same value for the ratio b, the differences in the data being in every case represented by differences in the coefficient a. The value thus obtained for b corresponds to the light ratio 0·4028 for descending, or 2·4827 for ascending magnitudes."

The Dunsink Observations.

During the past year Part III. of the *Astronomical Observations and Researches at Dunsink* has been published. The part contains four papers, two of which are by Dr. Brunnow and two by Dr. Ball.

Dr. Brunnow has compared the declination of the planetary nebula H. IV. 37 with that of a tenth magnitude star north preceding. Measurements were made on 33 nights, and the resulting value for the parallax is

$$+0''\cdot047 \pm 0''\cdot030.$$

Dr. Brunnow also gives a series of measurements of 82 double stars.

Dr. Ball has observed on 35 nights the difference of declination between the preceding star of 61 *Cygni* and a star of 9–10 mag. following. The resulting value of the parallax is

$$+0''\cdot4654 \pm 0''\cdot0497.$$

A first instalment is also given of the results of a search in the hope of finding stars with appreciable parallax. The present paper contains observations of 42 stars in which a negative result has been arrived at. Many of the stars in this list are taken from Schjellerup's Catalogue of Red Stars.

Astronomical Bibliography.

Under the title of "Répertoire des Constantes de l'Astronomie" M. Houzeau, the Director of the Royal Observatory at Brussels, has published, in vol. i. of the new series of the *Annals* of that institution, a very valuable contribution to Astronomical Bibliography.

Every practical astronomer feels keenly the difficulty of ascertaining the results that previous astronomers have obtained in any particular branch of the science, and those who have endeavoured to smooth these difficulties by bibliographical researches are deserving of his gratitude. To this end M. Houzeau has laboured in the preparation of a work which, dealing with the principal elements of practical astronomy, affords not only references to the publications wherein those elements may be found, but also in numerous cases furnishes the very details the astronomer requires for his researches.

The "Répertoire des Constantes de l'Astronomie" consists of nineteen chapters, each containing many subdivisions; each subdivision is prefaced by a paragraph of a general historical nature. Chapter 1, on Spherical Astronomy, has subdivisions dealing with the Obliquity of the Ecliptic, Precession, Nutation, Aberration, and Refraction; the values of these several constants as determined by astronomers from the earliest period to the present day being arranged in chronological order, with the authors' names and references to the works in which they are to be found. For example, 102 determinations of the obliquity of the Ecliptic are given for dates ranging from Tcheou-Kong, B.C. 1100, to Airy, 1868.

Chapter 2 is devoted to the elements of the principal planets as found in ancient tables. Separate chapters, 3–13, are devoted to the Sun, Planets, Earth, Moon, and Asteroids. Subdivisions give, in chronological order, determinations of the Elements of the Orbit, Diameter, Mass, Rotation, Brightness, and Physical Condition of those bodies, together with corresponding details of the satellites, with full references to authors' names, dates of publication, and values obtained. In fact each chapter forms a fairly complete history of the physical astronomy of each member of the solar system. The remaining chapters are devoted to Comets; Meteors; The Solar System generally; Catalogues of Stars; Physical investigations of Stars, such as Photometry, Spectroscopy, Parallax, Proper Motion of Stars; Double Stars

and Nebulæ; the Zodiacal Light; the subdivisions of each chapter containing very succinct details conveniently arranged in a clear and intelligible form. M. Houzeau's work will be found a very useful table-book for daily reference; but it is to be regretted that it was not made a separate publication, so that it might be more widely available to working astronomers.

Hartwig's Paper on the Diameters of Venus and Mars.

In *Publication XV. der Astronomischen Gesellschaft*, Mr. E. Hartwig has published the results of heliometric measurements of the diameters of *Venus* and *Mars*, made at Strasburg by means of several of the small heliometers which were employed in some of the expeditions for observing the last transit of *Venus*, and he has also collected and discussed, and partly reduced, the older series of observations. An examination of the different determinations of the diameter of *Venus* shows that almost all the measurements are affected by comparatively large constant errors, the sources of which can only be partially traced. Rejecting as untrustworthy the observations, made with wire micrometers and with double-image micrometers, the optical errors of which have not been investigated, Hartwig considers that only three series of measurements, namely those made by Main of Oxford, by Kaiser of Leiden, and by himself, can claim to have contributed to a knowledge of the diameter of the planet, and he deduces from them $17''{\cdot}55$ as the value of the diameter of *Venus* seen by reflected sunlight at a distance equal to the mean distance of the Earth from the Sun. This value is about $0''{\cdot}6$ greater than that derived from the measurements of the black disk of *Venus* made during the last transit by Auwers and by Col. Tennant.

In the case of *Mars* Hartwig combines finally the results of the observations of Bessel, Kaiser, Main, and himself, and deduces $9''{\cdot}352$ as the value of the diameter (at the distance 1), which is only a little greater than the value $9''{\cdot}328$ resulting from Bessel's old measures alone.

It is to be hoped that Hartwig's valuable paper, by exhibiting the present state of our knowledge of the diameters of the two planets, may help to induce capable observers to undertake such series of measurements as will be really creditable to the art of observing.

Lord Rosse's Observations of Nebulæ and Clusters.

In the *Philosophical Transactions* for 1844, 1850, and 1861, the late Earl of Rosse published extracts from the observations of Nebulæ and Clusters made with his 3-foot and 6-foot Reflectors. These observations have been, with a few interruptions, carried

on from 1848 up to the middle of 1878, and the present Earl has now published, in the *Transactions of the Royal Dublin Society* (New Series, vol. ii.), a very complete continuation of the earlier papers. As the latter only contained a selection from the observations, and in many cases gave very little information about new objects found at Birr Castle, it was considered desirable, not only to publish the observations made since 1860, but also to give at greater length the earlier ones. To facilitate the preparation of the work for publication, it was divided into three parts, the two first of which, comprising the first fourteen hours of R.A., were published last autumn, while the third part, containing the last ten hours, is in the press and will follow in a few months.

The observations made during the last six or seven years before the series was finished contain a great many micrometric measures of groups of nebulæ or of nebulæ and neighbouring stars, made to a great extent in order to verify the new objects found during previous years. For obvious reasons the absolute positions of the objects examined cannot be directly obtained, and this circumstance, combined with the very condensed form of the earlier publications, made it impossible for Sir John Herschel to avoid making many mistakes in entering the "R. Novæ" in his General Catalogue. Many of these mistakes were pointed out with more or less certainty by D'Arrest. In the new publication particular attention has been paid to the identification of the objects and the finding of exact places for the new nebulæ, and Mr. Dreyer, by whom most of the work of preparing and arranging the observations for publication has been performed, has, in brackets, added a considerable number of notes and remarks, chiefly relating to questions of identification. The brighter and more striking nebulæ having been frequently delineated, and drawings of them published in the former papers, there has therefore remained in recent times less scope for the pencil. The engravings in the *Philosophical Transactions* have not been reproduced in the new paper, but are only referred to in notes; while four lithographic plates contain drawings of nebulæ which either were not figured in the earlier papers or which appeared to have been less successfully represented by the earlier observers. To this latter class belong two of the most remarkable objects in the heavens, the so-called "Crab Nebula" (M. 1), and the great Spiral in the *Canes Venatici* (M. 51). Of both these carefully executed drawings are given, founded on a great number of observations, and believed to be faithful representations of the objects as they appear in the 6-foot Reflector. Diagrams, executed by the pantagraph process, are introduced in the text to show the relative positions of groups of nebulæ or of nebulæ and stars. In some cases they represent the appearance of objects of which only rough drawings had been made by the telescope.

The observations are given in the observer's own words, and none have been omitted, except such as were clearly inferior,

through weather or other causes, to others of the same object made under manifestly better conditions, and mere notes, only stating that an object had been viewed, without giving any details of description. While the first fourteen hours of R.A. in the paper of 1861 only occupied 34 pages, they extend over 130 pages in the present publication; and Lord Rosse is to be congratulated on the completion of this valuable series of observations.

Investigations in Optics, with special reference to the Spectroscope. By Lord Rayleigh.

Lord Rayleigh has published during the past year a series of four papers in the *Philosophical Magazine*,* in which he discusses several questions of interest to spectroscopic observers. He shows that, with beams of rectangular section, such as are usually made use of in both grating and prism spectroscopes, the diffraction phenomena are independent of the vertical aperture or height of the prisms, and that a double line in a spectrum cannot fairly be resolved unless its components subtend an angle exceeding that subtended by the wave-length of light at a distance equal to the horizontal aperture. For the best definition the angular width of the slit should not exceed a moderate fraction of the above angle.

It has long been known that the resolving power of a telescope may be increased by blocking out the rays from the centre of the object-glass, and Lord Rayleigh shows theoretically (and has also experimentally proved) that a similar increase of resolving power of a spectroscope may be obtained by blocking out vertical sections of the rectangular beam. In the second and third papers the influence of aberration and the amount of accuracy required in optical surfaces is investigated, and in the number for January 1880 the general design of spectroscopes is discussed.

The Selenographical Society.

This Society was founded at the beginning of 1878 by several Fellows of the Royal Astronomical Society interested in lunar work. The first annual report of the Society shows that it then consisted of 60 members, a number which has since been largely increased, and it now includes many astronomers in Australia, North and South America, and the principal States of Europe, from whom the most cordial support and encouragement has been received. Although only some two years old, as regards the number of its members, the progress in its special work, and its financial state, it may be considered to be in an established and satisfactory condition.

* *Phil. Mag.* October 1879 to January 1880.

The Society, in addition to the obvious advantages which may be expected from the combined efforts of its members, has certain special objects in view, such as the revision of the present, or the initiation of a standard, nomenclature, the production of a good map, and the exact delineation of as much as possible of the lunar surface. The last is a work of some importance, as it is likely to lead to some definite result on the question of lunar changes.

Since April 1878 a journal has been regularly published every lunar month (appearing on the day of new moon) treating of lunar matters, and giving amongst other things a list, with notes, of objects favourably situated during the next coming lunation, and from time to time outline maps, instructions and directions to observers, drawings, and photographs.

A collection of books, drawings, maps, photographs, &c. has already been formed by the Society.

Report on the Progress of Meteoric Astronomy in the Year 1879–80, by Professor Alexander Herschel.

Papers and essays on meteoric subjects, and occasional notes of observations relating to aërolites, meteors, and meteor showers were published during the past year, or were communicated to the Luminous Meteor Committee of the British Association pretty frequently, with about their usual abundance. Owing partly to the increasing range and progress in theory and practice of the subject of meteor-registration, producing as a natural consequence of its development a more varied and scattered form of its materials; and partly owing to losses in efficiency and organisation which the Meteor Committee of the British Association sustained last year by the death of one, and by the retirement of another of the active members of its staff, sufficient progress has not yet been made in reviewing writers' memoirs, and in selecting and extracting from details of observations the chief points of valuable and important interest which they contain, to enable the chief meteor events of the past year to be clearly described, and to be satisfactorily and adequately represented in a brief report.

There is no very pressing or urgent need to refer in this year's Report to the more insignificant phenomena of last year's meteoric displays; and it is to be hoped that the Council's Report will not suffer any material loss of scientific consequence if discussion of the phenomena of the smaller meteors is deferred to the more convenient season of another year.

The following list contains particulars of recent falls of aërolites, and a collection of results obtained from combinations and comparisons with each other of observations of several considerable fireballs of whose real paths determinations have recently been made.

Real Paths of Large Meteors, and Falls of Aërolites recently recorded.

Date and Hour of Appearance, G.M.T. (or Local Time); and general Locality.	Place of Fall; or Height (in English miles, m.) and Locality at Appearance and Disappearance.	Radiant-point, Length of Path, and Velocity.	General Description; Reference; and Comparison with known Radiant-points.
1864, Nov. 11 (5^h35^m p.m.) South of France; Ryde and Kent, England.	From 70 or 80 m. over a point midway between Lyons and Clermont, to 50 or 60 m. over a point midway between Cahors and Montauban.	85°+35° (±10°), near θ *Aurigæ*; about N.E., alt. 5° or 10°. 150 or 200 m. in about 5 seconds; 35 miles p. sec. Parabolic speed $32\frac{1}{2}$ m. p. sec.	At dusk, in full moonlight, which it eclipsed in Arriège. White, with a voluminous white tail, and persistent streak behind it; the latter visible on its whole course for several minutes. No appearance or sound of an explosion. (*British Assoc. Reports*, vol. for 1865, pp. 78, 120; with an additional observation at Ryde, *Ib.*, vol. for 1879, p. 108, where the date is in error). Corder 1876, Nov. 8, 9, 10, a special radiant-point of large meteors at 86°+36°.
1868, Sept. 5 ($8^h\cdot 5^m$ p.m. Berne Time). Switzerland, Italy, and France; and Germany.	From 250 m. over Belgrade (beginning perhaps even earlier) to 85 or 100 m. (? 70, or ? 115, not very certain) over Ozaine, near Tours, France.	14°−2°, near 20 *Ceti*. 1200 m. (or ? even more) in 43 seconds (average estimated duration); about 28 m. p. sec. (and perhaps swifter ?). Parabolic speed 26 m. p. sec.	A splendid, long-pathed fireball, widely and pretty carefully observed. Nucleus with little colour, tail, or enduring light-streak on its course; disappeared rather suddenly, without sound or appearance of explosion. The real path (with omission here of about a third part of its computed height and calculated extent at its commencement) by G. von Niessl (*Verhandlungen des Naturforschenden Vereins in Brünn*, Bd. xvii.); Schmidt, Sept. 1–10, 17°+9°; and Denning 19 (1876).
1878, July 15 (1^h 45^m p.m.) Stonefall in Moldavia.	Tieschitz (one stone only found). The meteor passed over Daubrawic and Sloup.	68°+40°; from about azimuth 108°, alt. 40°.	A stone of 27·5 kgm. fell from a small dark cloud, with loud noise, 100 paces from some people who discovered it while still warm. It is roughly pyramidal, with a black crust, and resembles internally and externally the Pultusk stones (Jan. 30, 1868), but is finer than them in texture, and chondritic (*Denkschrifte der Naturwissenschaftlichen Classe, Akad. d. Wissenschaften*, Wien, Bd. xxxix., Nov. 1878).
1878, Dec. 30 (about 6^h 57^m p.m.) Ohio and Pennsylvania, U.S.	From 72 m. over Columbiana Co. to 17 or 18 m. over Tuscarawas Co., Ohio (a disruption), and proceeding farther to 12 or 13 m. above the earth.	90°+55° (±10°), near δ *Aurigæ*. The first part of the flight 85 m. in about 2 seconds (determinations not very certain).	Nucleus elongated, as wide apparently as the Moon's disk, and many times longer; greenish, bursting into red pieces near the end of its course without detonation (D. Kirkwood, *American Phil. Soc. Proc.*, May 2, 1879, p. 241). Denning, Dec. 31, 1872, and Dec. 30, 1878, 92°+57°. Several meteors from this radiant-point, and one of them as bright as *Sirius*.
1879, Jan. 12 (7^h 25^m p.m. Berlin Time). Prague, and the centre of Bohemia.	From 40 m. over the Sudetengebirge (in the N.E. of Bohemia, beginning perhaps earlier), to 9 m. over Rakonitz, 25 m. W. from Prague, passing about 18 m. over Prague.	133°+19° (±3°), near δ *Cancri*; about E.N.E., alt. 14°. 124 m. in 3–5 seconds (6 estimates); 18 m. p. sec. Parabolic speed 23 m. p. sec.	A very large detonating meteor, shaking houses in Prague and Rakonitz by its concussion. Distinct from the next one, though the meteors appeared within a few minutes of each other. 130°+20°, Dec. 21—Jan. 5, 1876–7, Denning; ♂ 1680, Dec. 26, 132°+21°·5; fireball, Jan. 19, 1877, Ireland, 135°·5+22° (von Niessl), doubtful agreements (?). Calculations by G. von Niessl, Vienna Academy *Sitzungsberichte*, vol. lxxix., May 8, 1879.
1879, Jan. 12 (7^h 32^m p.m. Berlin Time). Western part of Bohemia and Saxony.	From 78 m. over Pibram, in Western Bohemia, to 23 m. over Grosshain, near Dresden.	52°−10° (±5°), near γ *Eridani*, nearly from S. to N. 60 m. in 5 seconds, or 124 m. in 10 seconds (2 estimates); $12\frac{1}{2}$ m. p. sec. Parabolic speed 11 m. p. sec.	A fireball similar in appearance to the last, but less large and brilliant, and not apparently producing any detonation. 57°−12°, Jan. 4–20, 1877, Denning; and fireball of Jan. 7, 1877, England, 48°−11°. G. von Niessl, *Ibid.*

1879, Jan. 28 (2^h 28^m a.m.) Wisconsin and Michigan, U.S.	From near 100 m. over a point in N. lat. 44° 25′, long. 9° W. from Washington, to 26 m. (or ? lower) over Charlevoix, Michigan.	142°+14° (about, or from alt. 55°, S.W. by S.), between *Leo* and *Cancer*. About 124 m.; duration not noted, but the meteor's observed motion was rather slow.	An immense fireball; 4× the Moon's apparent width, casting off a perfect ring of fiery sparks, which followed it; and producing a violent explosion, like an earthquake's shock, in Traverse City, Michigan (D. Kirkwood, *American Phil. Soc. Proc.*, May 2, 1879, p. 243). Perhaps a Jan.–Feb. Cancrid; 133°+26°, Feb. 13, SZ. 32; ☄ 1833 Ω Jan. 27, 135°+25°.
1879, Feb. 22 (12^h 20^m a.m.) Essex, Suffolk, and Cambridgeshire.	50 or 75 m. over some point between Godstone and Guildford, Surrey, to 5 or 6 m. over a point between Haverhill and Newmarket, Cambridgeshire.	140°+5° (±7°), near the head of *Hydra*. A length of path of about 85 m. in 3–5 seconds may be gathered roughly from the observations.	A very vivid fireball; nucleus half the Moon's apparent diameter, white and green, then red; burst into fragments with a report like thunder heard in less than half a minute at Haverhill and at Saffron Walden, in Essex (*British Assoc. Reports*, vol. for 1879, pp. 87, 118). Stationary 4th mag. meteor at 145°+8°, Feb. 24, 1878, E. F. Sawyer; 141°–2°, Jan. 1—March 16, Greg No. 16, 1876.
1879, Feb. 24 (2^h 53^m a.m.) York, and East Yorkshire. Seen also as far as Dundee, and Shoreham, near Brighton.	From about 60 m. above a point on the North Sea 28 m. N.E. from Whitby (first appearance probably still earlier) to 6 or 7 m. over a point halfway between Leeds and Selby.	310° (±15°) + 55° (∓10°), near χ *Cephei*. A good average direction, 39° E. from N., alt. 32°, with rather more probability of the upper than of the lower-signed corrections of the place. About 102 m. in 6 or 8 seconds by several estimations; 14½ m. p. sec. Parabolic speed 18 m. p. sec.	A fireball with immense illumination over York. Disk ½ or ⅛th of the Moon's apparent size, and light like daylight. White, or reddish with red tail at distant points of observation; sparks, and a disruption overhead at York, but no light-streak left upon its course, and the final disappearance rather sudden. A deafening report at York, with a concussion at Stockton like an earthquake's shock, a minute and a half after the appearance. No known radiant-point at the same date agrees with the observed position. Calculation of the real path by J. E. Clark, *British Assoc. Reports*, vol. for 1879, p. 89 and p. 118, where the time of appearance (12^h 45^m a.m.) is in error; and *The Observatory*, vol. iii., p. 304 *et seq.*
1879, May 10 (5^h p.m.) A stonefall in Iowa, U.S., America.	The large mass fell at Esterville, Emmet Co., Iowa; a smaller one at 2 m. distance from it, and many small pieces fell in the vicinity.	The smaller mass penetrated the earth vertically to a depth of 4½ feet; the larger stone was dug out from a depth of 14½ feet in a stiff clay soil.	The masses, weighing respectively 500 lbs., 170 lbs., and a few ounces or pounds, fell from a meteor seen to explode in full daylight, with a noise like a long roll of thunder. They consist, in nearly equal portions, of stony matter and metallic nickel-iron (the latter apparently containing tin), which shows Widmanstättian structure. Some of the crystalline minerals included in the stony part are 2 inches thick. (*American Journal of Science*, vol. xviii., p. 77.)
1879, May 17 (about 4 p.m.) A stonefall in Silesia.	A stone fell near Gnadenfrei, and a rather smaller one 2 m. due N.E. from it in Schobergrund, villages between Reichenbach and Frankenstein, in Silesia.	The holes, 1 ft. and 8 in. deep, made by the stones were vertical. The explosive sounds came from S.E., and were heard in that direction from the place of fall much more generally and loudly than N.W. of it.	Two stones were found, 2 lbs. and 1½ lb. in weight. The former, seen to fall with a rushing noise about 70 seconds after a loud report (which was triple) and a rattling sound, was cold when found. The other, discovered accidentally a few hours later, was broken into many pieces by the finders. They are loose-textured, chondritic, with much interspersed nickel-iron. The sky was overcast, and no fireball was observed. Enquiries made on the spot by Prof. Galle, and the analyses by Prof. von Lasaulx. (*Monaths-bericht* of the Berlin Academy, July 31, 1879.)
1879, Sept. 23 (8^h 10^m p.m.) Over the centre of Scotland.	From 70 or 80 m. above Ben Nevis, to a height of 20 or 25 m., between Loch Oich and Loch Laggan. A projected course of 10 m., a little E. of the Caledonian Canal.	288°+48° (±5°), between ι *Cygni* and π *Lyræ*. 50 or 55 m. in between 3 and 4 seconds (duration well observed); 15 or 16 m. p. sec. Parabolic speed 15½ m. p. sec.	A fireball several times as bright as *Venus*, and casting considerable light. Bluish, globular, without sparks or streak; disappeared rather suddenly. Seen at Aberdeen, Edinburgh, Silloth, near Carlisle, and at many places in Scotland. Radiant of the great fireball of Sept. 24, 1876, over the English Channel, 285°+35° (±5°), near δ *Lyræ*; and speed of that meteor's flight, relatively to the earth, 15 m. p. sec. G. & H. B_s, Aug. 2—Sept. 25, 285°+44°; Heis B_r, Sept. 1–15, and Schmidt, Sept. 1–10, 290°+58°, agree nearly with these fireballs' radiant-points. Calculation of the real track, from several observations of the meteor's course, by Prof. Herschel.

Papers read before the Society from February 1879 *to February* 1880.

1879.

Mar. 14. Observations of Encke's comet, 1878. J. Tebbutt.

Les longueurs du pendule à séconde à Poulkova, à St. Pétersbourg, et aux différents points de la Russie occidentale, corrigées de l'influence produite par la flexion des supports du pendule construit par M. Repsold. Prof. A. Sawitsch.

A formula for reducing precession in right ascension and declination from Bessel's to Struve's constants. Prof. A. Krueger.

Observations of absorbing vapours upon the sun. E L. Trouvelot.

On the change in the errors of Hansen's lunar tables between 1848 and 1876. W. T. Lynn.

Note on η *Draconis*. W. T. Lynn.

Remarks on Mr. Sadler's paper in the January number of the *Monthly Notices*. C. G. Talmage.

Notes on a Persian MS. of Ulugh Beigh's catalogue of stars belonging to the Royal Astronomical Society. E. B. Knobel.

On the probable presence of oxygen in the solar chromosphere. A. Schuster.

On a new method of determining astronomical refractions. D. Gill.

Note on systematic errors in right ascension depending on magnitude. D. Gill.

On the computation of the heights of lunar mountains from photographic measurements. Prof. C. Pritchard.

Note on Gruithuisen's lunar crater "Schröter." J. Birmingham.

April 9. An apparently new variable star. J. L. E. Dreyer.

Ephemeris for physical observations of *Jupiter*, 1879. A. Marth.

Notes on large telescopes, with suggestions for mounting reflectors. A. A. Common.

On the desirability of photographing *Saturn* and *Mars* at the next conjunction. A. A. Common.

On some formulæ for expressing the value of the excentric anomaly &c. in functions of the mean anomaly. A. de Gasparis.

Note on the death of M. E. de Chazal. Lord Lindsay.

May 9. Observations of Brorsen's comet, February 1879. J. Tebbutt.

Meteor radiant points of April 9–12. W. F. Denning.

Catalogue of 222 stationary meteors. W. F. Denning.

Observations of Brorsen's comet, 1879. H. C. Russell.

Observations of Brorsen's comet. Lord Lindsay.

Two short and easy methods of correcting lunar distances. J. J. Astrand.

Note on Sir John Herschel's reference catalogue of double stars. Prof. C. Pritchard.

On the determination of the solar parallax from the parallactic inequalities in the longitude of the moon, and on the correction to Hansen's coefficient of the annual equation. E. Neison.

Order of publication of successive volumes of the *Observations de Poulkova* (extract from a letter to Mr. Downing). O. von Struve.

On the spectrum of Brorsen's comet, observed at the Royal Observatory, Greenwich. Astronomer Royal.

June 13. Observations of Brorsen's comet, February and March 1879. J. Tebbutt.

An important invention, giving perfectly uniform rotary motion in driving clocks. H. C. Russell.

Determination of the longitudes of Berlin, Munich, Leipzig, Vienna, Paris, and Pulkowa. T. Oppolzer.

On the values of the constants in the equation ${}_rA_r x^{(r)} + {}_rA_{r-1} x^{(r-1)} + \ldots + {}_rA_t x^{(t)} + \ldots + {}_rA_0 - y_x = 0$; obtained by the method of least squares, from the $n+1$ values of y_x when $x = 0, 1, 2, \ldots n$; n being greater than r. C. Carpmael.

On the value of the solar parallax derived from observations of *Mars* made at Ascension during the opposition of 1877. D. Gill.

On the knowledge of the zodiacal light possessed in the east from of old. J. W. Redhouse.

Spectroscopic observations of the motion of stars in the line of sight, made at the Temple Observatory, Rugby. G. M. Seabroke.

Note on the Cape catalogue of 12,450 stars (extract from a letter to the Astronomer Royal. E. J. Stone.

A new method of controlling the driving clock of an equatoreal. R. C. Johnson.

Preliminary note on the Babylonian astronomy. The Babylonian calendar. R. H. M. Bosanquet and A. H. Sayce.

On the coincidence of the bright lines of the oxygen spectrum with bright lines in the solar spectrum. H. Draper.

On the applicability of the mean refractions of Bessel's fundamenta to the Washington observations. A. M. W. Downing.

Note on the photographic semi-diameter of the moon. Prof. C. Pritchard.

Théorie analytique des mouvements des satellites de *Jupiter*. M. Souillart.

Note on the transit of the earth and moon across the sun's disk as seen from *Mars* on November 12, 1879, and on some kindred phenomena. A. Marth.

On a new method of mounting an equatoreal. Rev. J. Pearson.

Nov. 14. Ephemeris for physical observations of *Mars*, 1879. A. Marth.

Note on the difference of variation of gravity at Revel and St. Petersburg, and on Grischow's pendulum observations at other stations. Major J. Herschel.

On the physical configuration of *Mars*. W. Harkness.

On the change in the mean error of longitude of Hansen's lunar tables since 1876. W. T. Lynn.

Mean areas of umbræ, whole spots, and faculæ upon the sun's disk, as measured on photographs taken at the Royal Observatory, Greenwich, for each rotation of the sun from 1873, July 11. Astronomer Royal.

The nebula in the *Pleiades*. Maxwell Hall.

Observations of comets *Palisa* and *Hartwig* made with the Merz equatoreal of the *Collegio Romano*. P. Tacchini.

Conjunction of *Mars* and *Saturn* observed at the observatory, Melbourne. R. L. J. Ellery.

Comparison of Hansen's coefficients of the moon's latitude with those of Plana, Damoiseau, &c. R. Wilding.

The zodiacal light. Maxwell Hall.

Description of a self-registering micrometer. A. Bowden.

Observations of comet 1879 *d* (Palisa) made at Dun Echt observatory. Lord Lindsay.

Observations of the spectrum of comet 1879 *d* (Palisa). Lord Lindsay.

On a photograph of the solar spectrum showing dark lines of oxygen. J. C. Draper.

Note on the semi-diameter of the moon. E. Neison.

On the polarisation of the corona. A. Schuster.

A comparison between the right ascensions and north polar distances of the *Nautical Almanac* and the General Cape Catalogue for 1880. E. J. Stone.

On the evidence of a past connexion between four widely separated southern stars. E. J. Stone.

On the working of the speculum for the 37-inch reflector. G. Calver.

Note on two accompanying sketches of *Jupiter*. Captain W. Noble.

Note on the ellipticity of *Mars*, and its effect on the motion of the satellites. J. C. Adams.

Observations of the solar eclipse 1879, July 18, made at the University Observatory, Strasburg. A. Winnecke.

Dec. 12. Note on the correction to the mean longitude of Hansen's lunar tables. S. Newcomb.

Occultation of 64 *Aquarii* by *Jupiter*, observed at the Melbourne Observatory. R. L. J. Ellery.

The Babylonian astronomy, part II. R. H. M. Bosanquet and A. H. Sayce.

New double stars. S. W. Burnham.

Discovery of a gaseous nebula in *Cygnus*. Rev. T. W. Webb.

Sur la variation du demi grand' axe des orbites planétaires. A. de Gasparis.

Occultation of stars by the moon, and phenomena of *Jupiter's* satellites, observed at the Stonyhurst observatory. Rev. S. J. Perry.

The November meteors. Rev. S. J. Perry.

On recent changes in the mean error of longitude of Hansen's lunar tables. W. T. Lynn.

Note on the gaseous nebula in *Cygnus*. G. Knott.

On a form of reading microscope which appears to combine most of the advantages of the German and English forms. E. J. Stone.

Note on the north polar distances of the Greenwich seven-year catalogue for 1860. A. M. W. Downing.

Observations of the outer satellite of *Mars* made at Dun Echt observatory. Lord Lindsay.

Note on *General Catalogue* (Supplement) No. 6000. Lord Lindsay.

Observations of Mr. Baxendell's new star in *Canis Minor*. Lord Lindsay.

Note on the spectrum of the red spot on *Jupiter*. Lord Lindsay.

Note on the Rev. T. W. Webb's new nebula. Lord Lindsay.

On the correction for personality required by the observations of the moon made with the Greenwich transit-circle. E. Neison.

Observations of the satellites of *Mars*. A. A. Common.

Note on *Mimas* and *Hyperion*. A. A. Common.

Note on a new star in *Canis Minor*. G. Knott.

Ephemeris for finding the positions of the satellites of *Uranus*, 1880. A. Marth.

Note on Mr. Webb's new nebula. A. Winnecke.

1880.

Jan. 9. Observations of the phenomena of *Jupiter's* satellites &c., made at the observatory, Adelaide. C. Todd.

Meteor showers. W. F. Denning.

Observations of occultations of stars by the moon, and

of phenomena of *Jupiter's* satellites, made at the Royal Observatory, Greenwich, in the year 1879. Astronomer Royal.

Meteor showers, 1870–79. H. Corder.

On the rotation period of *Jupiter*. H. Pratt.

Note on the remeasurement of a lunar photograph, in reply to Mr. Neison's criticism. C. Pritchard.

Changes of relative brightness of *Jupiter's* satellites. C. E. Burton.

Notes on "a catalogue of 10,300 multiple and double stars" &c., forming volume xl. of the *Memoirs of the Royal Astronomical Society*. Hours o to vi. H. Sadler.

Note referring to observations and estimations of the brightness of *Mars* which ought to be made in February and March 1880. A. Marth.

Estimations of the time of transits of the red mark on *Jupiter* across the central meridian. T. W. Backhouse.

On the systematic errors of the Greenwich north polar distances. W. H. M. Christie.

Mean area of spots and faculæ upon the sun's disk, as measured on photographs for 1878 and 1879. Astronomer Royal.

Observations of the outer satellite of *Mars* made at the Royal Observatory, Greenwich. Astronomer Royal.

On the effects of personality on the tabular errors of the moon. E. Dunkin.

The Greenwich standard right ascensions. A. M. W. Downing.

On some changes in the markings of *Mars*. N. E. Green.

List of Public Institutions and of Persons who have contributed to the Library &c. since the last Anniversary.

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The Lords Commissioners of the Admiralty.
British Association for the Advancement of Science.
British Horological Institute.
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Neuchatel, Society of Sciences.
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Bombay Asiatic Society.
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Melbourne Observatory.
Royal Society of Victoria.
Philadelphia, American Philosophical Society.
Franklin Institute.
Sydney, Government Observatory.
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Erratum in the *Monthly Notices*, vol. xxxix. p. 506, line 12:
for 1843 *read* 1841.